Engineering Library
NOV 23 1916
UNIV. OF MICH. LIBRARY

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CII.—No. 2653.] *LONDON: FRIDAY, NOVEMBER 3, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST..8d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT,
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 5036

A. G. Mumford Ltd.,
CULVER STREET WORKS, COLCHESTER.
OR ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 39, last week.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS
And Auxiliary Machinery as supplied to the Admiralty. Od 3179

Harbour, Customs and Police LAUNCHES.
JOHN SAMUEL WHITE & COMPANY, LTD., Shipbuilders and Engineers, 5045
EAST COWES, I.W.

See's Patent Hydro-Pneumatic Ash Ejector.
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel—Apply, P. J. TREWHNT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4335

Petter Oil Engines.
Manufactured by
PETTERS LIMITED, Engineers, Yeovil.
See our Illustrated Advt. every alternate week. 3591

Craig & Donald, Ltd., Machine TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1268

FOR
Drop Stampings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, WELLINGTON STREET, GLASGOW. 5433

P. & W. MacLellan, Limited, CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 3547
Registered Office: 108A, Cannon St., London, E.C.

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS.
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH. 5008

Brett's Patent Lifter Co., LIMITED.
Hammers, Presses, Furnaces, COVENTRY. 610

Bever, Dorling & Co., Ltd., BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR-COMPRESSING and PUMPING ENGINES. 1266

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 4936

R. Heber Radford, Son & Squire, ENGINEERING, IRON AND STEEL WORKS.
Established} Valuers, over 50 years.
CONSULTING ENGINEERS, REFEREES, ARBITRATORS AND PATENT AGENTS. (Senior Partner, R. HEBER RADFORD, Mem. Inst. Mechanical Engineers, Mem. Inst. Naval Architects, Mem. Iron and Steel Inst., Fellow Chartered Institute of Patent Agents.
15, ST. JAMES ROW, SHEFFIELD. 4857
Telegrams: "Radford, Sheffield." Telephone: 626.

Telegrams—"Cylinders," Birmingham.
Weldless-Steel Tubes
for Water-Tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 3179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON).
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
Exceptional Shallow Draught
VESSELS PROPELLED BY STEAM
Turbines or
Internal Combustion Engines. Od 3759

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drilling & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3661
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 4988

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 92. 5020

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 5055

The Norman Thompson Flight Co., Ltd. (REGD. 1909.)
CONTRACTORS TO THE ADMIRALTY.
Seven years' experience
in Design and Construction of Aircraft.
"THE FIRM WHO GAVE THE FLYING BOAT TO THE NAVY."
ALL BRITISH BUILT.
Address:—MIDDLETON, BOGNOR, ENGLAND.
Telegrams—"Soaring, Bognor." 5266

"Gripoly"
MACHINE BELTING
FOR
Driving
—
Conveying
—
Elevating
—
SOLE MANUFACTURERS:
Lewis & Tylor, Ltd.,
CARDIFF. 5484
LONDON. MANCHESTER. GLASGOW.

Iron and Steel
Tubes and Fittings.
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 84, Robertson Street, Glasgow.
BRANCH OFFICES:
London, Liverpool, Manchester, Newcastle-on-Tyne, and Cardiff. 3865

Royles Limited, ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 4024

Tubes, Iron and Steel.
Edwin Lewis & Sons, 4922
London Office: 143, Cannon St., E.C. Wolverhampton.

Tubes and Fittings, IRON AND STEEL.
Stewarts and Lloyds, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—187, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—54, DEANSGATE.
CARDIFF WAREHOUSE—120, BUTE ST.
BIRMINGHAM WAREHOUSES—BROAD STREET CHAMBERS, SHERPCOTE ST., and 10, COLESHILL ST.
See Advertisement page 26. 4990

Cranes.—Steam and Electric.
STEAM NAVVIES, GRAB CRANES,
SHIPS DECK MACHINERY.
JOHN H. WILSON & CO., LTD.,
DOCK ROAD, BIRKENHEAD.
London Office:—15, Victoria Street, S.W.

Motors for Immediate Sale:—
52 HP., 3700 volts, 800 r.p.m., 3 phase, 40 periods, by Scott & Mountain. 35 HP., 600 volts, 980 r.p.m., 3 phase, 40 periods, by Scott & Mountain. 10 HP., 205 volts, 1300 r.p.m., D.C., by Sunderland Forge Co. 3½ HP., 200 volts, 515 r.p.m., D.C., by B.T.H. 2 HP., 500 volts, 2 pole, by Scott & Mountain. 2/3 HP., 100 volts, 2 pole, by Scott & Mountain. Excellent working condition and cheap.
JENNINGS,
West Walls, Newcastle-on-Tyne. 5256

Separators
— FOR —
EXHAUST STEAM TURBINES COMPRESSED AIR, &c.
STEAM DRYERS,
METALLIC PACKINGS.
Princeps & Co.,
SHEFFIELD. 5191

New Chicago Automatics,
Three Sizes, Delivery from Stock.
NEW CAPSTANS, 1¼ in. through the wire feed.
JOHN MACNAB, MARY STREET, HYDE.
Tel. No.: 78 Hyde. 5319

Cranes (Birmingham) Limited
153, MOSELEY STREET, BIRMINGHAM,
for
Die Castings
in White and Yellow Metal.
Drop Stampings
in Yellow Metal and Steel.

Mechanics and Metals
National Bank
OF THE CITY OF NEW YORK.
ESTABLISHED 1810.
CAPITAL (Fully Paid) - - - $5,000,000
SURPLUS & UNDIVIDED PROFITS $9,000,000
This Bank receives Accounts of Banks, Bankers, Corporations, Firms and Individuals on favourable terms, and grants to its depositors every facility consistent with prudent and conservative banking methods.
CORRESPONDENCE INVITED.
FOREIGN DEPARTMENT.
Finances Exports and Imports, Buys and Sells Foreign Exchange, Telegraphic Transfers, &c., and makes Collections on all parts of the world.
LONDON BANKERS. 5462
LONDON JOINT STOCK BANK, LTD.,
LONDON, CITY & MIDLAND BANK, LTD.

Yarrow Patent
Water-tube Boilers. 4985
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3866

Head, Wrightson & Co.,
LIMITED,
See Advertisement page 30, Oct. 27. 2403

Taylor & Challen
Presses. 3199

Locomotives in Stock.—
KERR, STUART & CO., LTD., have in stock or in an advanced state of progress at their California Works, Stoke-on-Trent, a large number of LOCOMOTIVES, with cylinders from 8 in. to 16 in. diameter (inclusive), for all gauges from 18 in. to 4 ft. 8½ in.—Apply to KERR, STUART & CO., LTD., 5, Broad Street Place, E.C. 4970

Railway
Switches and
Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 5449

Matthew Paul & Co., Ltd.
LEVENFORD WORKS. Dumbarton. 3304
See Full Page Advt. page 46, Oct. 20.

GOLD MEDAL—INVENTIONS EXHIBITION—AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD., LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 17. 5008

CHANTIERS & ATELIERS
Augustin - Normand
67, rue de Ferrey—LE HAVRE (FRANCE).
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarines and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines. 3900

Rubber MANUFACTURERS
Valves and Packings
GUTTA PERCHA & RUBBER, LIMITED.
Toronto - - Canada. 5211

B. & S. Massey, Ltd., MANCHESTER.
Steam Hammers,
Power Hammers,
Drop Stamps,
Band Saws.
QUICK DELIVERY. LARGE STOCK 4969

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir W. FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5169

A National Need.

BRITISH SCHOOL OF AERONAUTICS.
Aeroplanes and Airships. Construction, Design and Draughtsmanship. Complete Postal Courses. Also preparation for Exams. of Institutions of Civil, Mechanical and Electrical Engineers.—PENNINGTONS, 264, Oxford Road, Manchester. 5397

STRUCTURAL ENGINEERING.

For Particulars of Course of

INSTRUCTION by CORRESPONDENCE, write to "THE WESTMINSTER ENGINEERING BUREAU," 22, Old Oak Road, Acton Park, London, W. 5471

TENDERS.

CITY OF MANCHESTER.

The ELECTRICITY COMMITTEE of the MANCHESTER CORPORATION are prepared to receive

Tenders for the Sale of the

following PLANT:—
A.—BLOOM STREET GENERATING STATION.
One 1800 Kw. Slow-speed Continuous-current GENERATOR, direct-driven by a vertical cross-compound steam engine.
B.—STUART STREET GENERATING STATION.
One 3750 Kw. Slow-speed, 3-phase, A.C. ALTERNATOR, direct-driven by a vertical triple-expansion steam engine.
The plant is working daily, and may be inspected at the works named above.
Specifications of the Plant may be had from Mr. F. E. HUGHES, Secretary, Electricity Department, Town Hall, Manchester.
Further particulars and information may be obtained from Mr. S. L. PEARCE, Chief Electrical Engineer, Dickinson Street, Manchester.
Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall not later than Ten o'clock a.m. on Wednesday, 22nd November prox.
The Corporation do not bind themselves to accept the highest or any Tender.

THOMAS HUDSON,
Town Clerk.

Town Hall, Manchester,
30th October, 1916. F 400

CONTRACTS, &c.

GREAT SOUTHERN AND WESTERN RAILWAY (IRELAND).

CONTRACTS
FOR YEAR ENDING DECEMBER, 1917.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES for twelve months to 31st December, 1917, or part of that period.

	No. of Form.		No. of Form.
Acid, Sulphuric	3D	Hair, Curled	7B
Baskets	10	Hardware (Sundry)	17
Bolts, Nuts & Rivets	15	Incandescent Fittings for Gas	36C
Brooms and Brushes	13	India Rubber Goods	9A
Brass Fittings for Carriages	18	Implements (Sundry)	21
Do. do. for Lamps	18A	Iron Tubes and Fittings	29
Do. do for, Water	36A	Iron and Steel Wire	30A
Do. do. for Gas	30B	Leather	12
Bunting	7B	Linen	6
Canvas and Sacks	6	Linoleum	7B
Carriage Lace	7A	Locks and Keys	19
Castings, Mall. Iron	11	Mats, Fibre	10
Cement	34	Morocco	7B
Cloth (Carr. and Uniforms)	7C	Nails	31
Clothing, Oil	9B	Oak Keys	35A
Do. I.-R. proofed	9B	Oak Trenails	35B
Coach Screws and Washers	15	Plumbago	41
Colours	2	Railway Fastenings (Iron)	16
Corks	39	Rain Water Pipes and Gutters	25
Cotton Waste	5A	Ropes, Twine and Yarn	4
Crucibles	41	Sewer Pipes, Plaster, &c.	39
Curled Hair	7B	Shovels, Spades, &c.	31A
Drysalteries	3	Soft Goods	8
Emery and Glass Cloth, &c.	28	Sponge Cloths	5
Files and Tool Steel	20	Signal Wire Pulleys	11
Fire Bricks and Clay	33	Screws and Split Pins	14
Fish Bolts (Steel)	16A	Tin Plates	23
Foundry Requisites	42	Varnishes	1
Galv. Sheets, Buckets, &c.	23	Waste	5A
Grates, Stoves, and Founders	24	Waterproof Clothing	9B
Grindstones	26	Wicks	6
Glass, Sheet and Plate	37A	Wire, Fence and Signal	30A
Glass and China Sundries	37B	Wirework	30B

Forms of Tender can be obtained on *PAYMENT* of 6d. each from the COMPANY'S STOREKEEPER, AT THE GENERAL STORES, INCHICORE, Dublin, to whom enquiries for information should be made direct. Patterns may be inspected at the same place, on and after the 30th instant, between the hours of Ten a.m. and Four p.m. (except on Saturdays).

The Tenders to be sent in endorsed "Tender for Stores," and addressed to the undersigned, so as to be with him before Ten o'clock a.m., on Wednesday, the 15th November, 1916.

The Directors will not consider any Tender except those furnished on the Company's Forms, and do not bind themselves to accept the lowest or any Tender.

By Order,
ROBERT CRAWFORD, Secretary.

Kingsbridge Terminus, Dublin.
October, 1916. F 404

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1917.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of January next, and terminate on the 31st of December, 1917.

	No. of Form.		No. of Form.
Asbestos and Packing	1	Oils and Tallow	26
Barrows and Trucks	2	Paints, Colours and Wallpaper	27
Baskets and Mats	3	Ropes and Canvas	28
Brushes, Brooms, &c.	4	Rail Fastenings, Iron	29
Brass Fittings for Gas and Water	5	Do. steel	30
Bolts, Nuts & Rivets	6	Screws, Split Pins, Nails, &c.	31
Bricks, Slates, Earthenware Pipe, &c.	7	Sheet Tin, Lead, Gun Barrel, &c.	32
Chain	8	Steel Tyres, Axles and Plates	33
Cement	9	Steel & Copper Tubes, Copper Plates and Ingots	34
Candles and Soap	10	Steel Castings	35
Carriage Fittings	11	Staffordshire Iron, Wire, &c.	36
Do. Trimmings	12	Springs, Steel, and Files	37
Creosote Oil	13	Soft Goods	38
Drysalteries	14	Timber, &c.	39
Fog Signals	15	Tools	40
Glass	16	Tool & Barrow Shafts	41
Grease	17	Varnishes	42
Gas Mantles, &c.	18	Wagon Covers and Tapaulins	43
Iron & Steel Forgings	19	Waste and Wicking	44
Iron Castings	20	Yorkshire Iron	45
India Rubber Goods	21		
Lime	22		
Leather and Belting	23		
Lamps and Tinware	24		
Locks, Rainwater Goods & Hardware	25		

Forms of Tender can be obtained, on payment of Sixpence each, from the STOREKEEPER, GENERAL STORES DEPARTMENT, BROADSTONE STATION, DUBLIN. *Please do not send Stamps.*

Patterns and samples can be inspected at the same place on and after 1st prox., between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon).

Contractors cannot be allowed to tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.

The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.

The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No.....," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before Ten a.m. on the 14th November.

The Directors do not bind themselves to accept the lowest of any Tender.

By Order,
PERCY A. HAY, Secretary.

Broadstone Station, Dublin,
October, 1916. F 379

APPOINTMENTS OPEN.

Master Required, to Take

charge of engineering laboratory and workshop which are to be set up in the near future. Candidates, who must be ineligible for military service, should have had some experience in modern workshop practice. In the meantime, until there is sufficient work on the engineering side, the master would be required to help with some of the school work, e.g., elementary, mathematics, &c. Duties to commence at once, or after the Christmas holidays. Salary £180 per annum, rising by £5 to £200.
Apply at once to HEADMASTER. F 399

NORTHAMPTON POLYTECHNIC INSTITUTE, LONDON, E.C.

Applications are Invited for

the following full-time vacant APPOINTMENTS in the CIVIL AND MECHANICAL ENGINEERING DEPARTMENT:—
(1) Demonstrator and Assistant Lecturer. Salary £140 per annum.
(2) Laboratory Mechanic and Junior Demonstrator, with good practical knowledge of the working of Heat Engines. Salary £120 per annum.
Particulars and forms of application for either of the above can be obtained on application to—
R. MULLINEUX WALMSLEY, D.Sc.,
Principal. F 356

Wanted, Works Manager for

a firm of heavy chemical manufacturers in Cheshire. Preference will be given to one having a good knowledge of the running of large steam engines or turbines, a knowledge of general mechanical and electrical repairs, &c., and a knowledge of the handling of men. The applicant must be a practical man, and have a good memory. Salary (according to experience and ability) £350 to £450 per annum. Applicants must give full details of their experience, age, salary required, &c.
Address, F 383, Offices of ENGINEERING.

Wanted, Assistant Works

MANAGER for medium sized shop engaged largely on shell work; take complete charge of shell contract under general manager. Salary £500 per annum.—Apply, F 402, Offices of ENGINEERING.

Assistant to Manager Re-

QUIRED in engineering works, situated in Midlands, Government controlled. Must have sound commercial knowledge and familiar with up-to-date systems. Replies must state full particulars, giving experience, salary expected, and present employment. Information will be treated confidentially. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and F 414.

Tea Gardens in India.—

ENGINEERS WANTED. Must be qualified and capable men. No one eligible for the Army need apply. Salary offered Rs. 250 a month, with allowances and yearly increase. First-class passage will be provided.—Apply, by letter, with copies of testimonials, to TEA, care of POTTLE & SON, Royal Exchange, London, E.C. F 402

Chemical Engineer Required,

with practical experience of Nitric Acid, Sulphuric Acid Concentrating, Acid Mixing and Denitrating Plants. Must be good mechanical engineer, with some knowledge of Electrical Plant, and capable of handling men with tact. Please state age and full particulars of experience. Applications can be made in writing through your nearest LABOUR EXCHANGE, mentioning this Journal and F 363. No person engaged on Government work will be employed.

Refrigerating Engineer

WANTED, first-class Board of Trade certificate and experience with ammonia desirable; must be ineligible for military service. No one already engaged on Government work will be considered.—Apply by letter, stating age, if married, and giving details of experience to BOX No. 221, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, E.C. F 412

Engineer Wanted for Works

in Glasgow, employing about 1000. Excellent opening for really competent man who can take complete charge of production. Works at present engaged on urgent War work. Expert knowledge of modern tools and methods of production, together with experience of heavy machinery, essential. Give fullest details of experience and training and state salary required. No person already employed on Government work will be engaged. — Apply, your nearest LABOUR EXCHANGE, mentioning this Journal and F 347.

Mechanical Engineer for

Russia.—WANTED, highly qualified MAN, to organise technical department of large Importing House acting as agents and merchants for leading British manufacturers of industrial machinery, prime movers, &c. Must have previous Russian experience. Attractive terms will be offered for thoroughly competent man with good connection.—Apply by letter, stating age, salary, and qualifications, to "RUSSIA," care of A. M. SILLAR, 40, Broadway, Westminster, S.W. F 353

Responsible Engineer Wanted

to take complete charge of small Munition Factory power plant on South Coast. Paraffin generating sets, electric motors, lighting, telephones, &c. Must be competent to get out plans for extensions. Highest references only.—Apply, giving details of experience and copies of testimonials, to the nearest LABOUR EXCHANGE, mentioning this Journal and F 392. No person already employed on Government work can be engaged.

Chemist, for Non-Ferrous

metal analyses, and the melting of metal.—Write, stating experience, age, and salary required, to JOHN WRIGHT & CO., Essex Works, Aston, Birmingham. F 395

Representatives Wanted for

well-known firm of coal cutter and coal face conveyor makers. Applicants should have mechanical and electrical knowledge, and those selected will be required to spend a few months in works and various mines to obtain first-hand experience. Only applicants prepared to devote whole time to the work will be considered.—Address, F 409, Offices of ENGINEERING.

Accountant Book-keeper Re-

QUIRED, to take charge of invoices, accounts, and ledgers, able to prepare monthly balance sheet. One having experience in locomotives preferred. No person already on Government work will be engaged.—State age, salary required, and experience, to your nearest LABOUR EXCHANGE, quoting No. A 2463. F 397

Junior Required, having Good

knowledge of theoretical mechanics, hydraulics, and electricity; unfit for military service.—Address, F 406, Offices of ENGINEERING.

Superintendent Required, for

machine shop in the Midlands, for motor and aero engine work. Good opportunities for a really live up-to-date and experienced man. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2296 F 415

Wanted, a High-class Experi-

enced Leading DRAUGHTSMAN, expert in uniflow and heat extraction engine design; good salary to suitable man. No person already employed on Government work will be engaged.—Apply, stating age, experience, &c., to your nearest LABOUR EXCHANGE, mentioning this Journal and F 342.

Wanted, Three Draughtsmen

thoroughly conversant with either Blast Furnace or Steel Works practice, for large Government controlled Iron and Steel Works on the North West Coast. Permanency to suitable men.—Applications should be forwarded to the nearest LABOUR EXCHANGE, quoting No. A 2322. Draughtsmen already engaged on Government work cannot be engaged. F 394

Wanted, a Neat and Reliable

DRAUGHTSMAN, experienced in the preparation of steam turbine details. No person already on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2499. F 408

Wanted, Immediately,

DRAUGHTSMAN used to small electrical work.—Apply, stating qualifications, age and salary required, to nearest LABOUR EXCHANGE, quoting No. A 2501. No one already engaged on Government need apply. F 407

Wanted, in London,

DRAUGHTSMAN, with general experience. No person resident more than 10 miles away, or already employed on Government work or liable for military service, need apply.—Address, stating qualifications, age, salary required, F 386, Offices of ENGINEERING.

Draughtsman, Mechanical,

WANTED, for mining machinery; experience with gearing a recommendation. Yorkshire West Riding. Give full particulars and salary required.—Address, F 377, Offices of ENGINEERING.

Good Draughtsman Wanted,

with automobile or aero engine experience by controlled firm in the Midlands. No person engaged on Government work need apply.—State age, experience, and salary required, to nearest LABOUR EXCHANGE, mentioning this Journal and F 242.

Draughtsman for Jigs and

Tools, with shop experience; permanent position. No man on Government work will be engaged.—Write, stating qualifications, age, salary required, and earliest date can commence, to your nearest BOARD of TRADE LABOUR EXCHANGE, mentioning this paper and No. A 2455. F 314

Electrical Draughtsman

WANTED, capable of designing windings, &c., for heavy A.-C. and D.-C. mining motors. Give full particulars and salary required.—Address, F 378, Offices of ENGINEERING.

Jig and Tool Draughtsmen

REQUIRED immediately, for motor or aero work. No person on Government work or eligible for the army will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2486. F 398

Required by Firm of Consult-

ing Engineers, Reliable Engineering DRAUGHTSMAN with experience in power station lay-out schemes, and general electrical and mechanical and constructional work. Applicants should state fullest details of education, training, and experience, age, if married, and form of exemption from military service. No application will be considered from persons already on Government work. Good salary paid to suitable man.—Address, F 365, Offices of ENGINEERING.

Assistant Draughtsman

WANTED, for marine auxiliary machinery. State experience and wages expected. No person already engaged on Government work, or residing more than 10 miles away, need apply.—Apply by letter, to CAIRD & RAYNER, 777, Commercial Road, Limehouse, E. F 401

Experienced Lady Tracers

WANTED. No person already employed on Government work will be engaged. Must be quick and accurate.—Send samples of work, stating salary and full particulars, to nearest LABOUR EXCHANGE, mentioning this Journal and F 343.

Foreman Wanted for Con-

tractors' Smithshop in Dublin. 10 fires and machine tools for manufacture of light steel structures, roofs and buildings, iron fences, railings and gates, general smithwork, and cold angle framing. Over 30 to 40 men.—Reply, stating age, experience and wages expected, to your nearest LABOUR EXCHANGE, quoting No. A 2453. Only ineligible men not employed on Government work need apply. F 320

Storekeeper (Chief) Required,

for large motor works in Midlands. Capable of controlling staff. Only applicants used to large stock and up-to-date systems will be considered. No one already engaged on Government work need apply. State age and salary required, and send copies of references.—Write, to your nearest LABOUR EXCHANGE, quoting this paper, and reference No. A 1555. F 381

Engineering Pupil.—Vacancy

with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 6321, Offices of ENGINEERING.

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4389, Offices of ENGINEERING.

SITUATIONS WANTED.

Works Manager, having been

responsible for the successful production of Rotating Cylinder Aircraft Engines with firm of Agricultural Engineers, also wide experience of general engine production, is now free to ACCEPT another POSITION.—Address, F 416, Offices of ENGINEERING.

Practical Production Engineer

and Works Manager, with considerable experience in the production of aircraft of various types, can shortly be at liberty, and SEEKS POSITION of responsibility. Experienced organiser, and successful in control of mixed labour. Expert in factory equipment.—F 419, Offices of ENGINEERING.

Electrical Engineer and

Designer, A.M.I.C.E., DESIRES CHANGE. Specialised on turbo-machinery and power plant; 6½ years' shops, 12 years' designing and technical work. Age 34, ineligible, post abroad preferred.—Address, F 351, Offices of ENGINEERING.

Engineer, Trained Marine

work, experience principally same; designer, draughtsman; accustomed taking charge; WISHES OPENING, with prospects. Works or dept. manager, correspondence, &c.—Address, F 390, Offices of ENGINEERING.

Mechanical Engineer and

DRAUGHTSMAN, age 42 years. 24 years general engineering. Last 12 years design and construction of gold mine plants. Excellent references.—Address, F 388, Offices of ENGINEERING.

All Round Engineer (36),

with workshops, d.o. and University training; many years successful charge designer, DESIRES POST; non-sedentary preferred, but not essential.—Address, F 411, Offices of ENGINEERING.

Engineer or Draughtsman

(43), just DISENGAGED; used to planning, superintendence and erection of Mechanical, Civil or Chemical plants.—Address, F 387, Offices of ENGINEERING.

Well Educated Lady, Seeks

POSITION as Tracer. Used to engineering work.—Address, F 417, Offices of ENGINEERING.

SPARK IGNITION.

An Investigation of the Effect of Spark Intensity on Ignition in Internal Combustion Engines.

By J. D. Morgan, A.M.I.C.E., A.M.I.E.E.

There are current among engineers two opposed beliefs regarding the effects of spark intensity on ignition in internal combustion engines. According to the one, provided a spark is sufficiently strong to produce ignition, an increase of strength has no effect on either the rate of combustion or the maximum pressure attained; consequently such increase has no effect upon the power developed by the engine. According to the other the strength of the spark does have an effect upon the power, and it is therefore assumed that the spark strength influences both the rate of combustion and the maximum pressure attained. Obviously both assertions cannot be true, yet it is possible that the one which is untrue has some foundation in fact, and has arisen out of a misinterpretation of experimental results.

Regarding the terms "strength" or "intensity" as applied to sparks for ignition purposes, no clear meaning is or can be attached to them. The terms are unsuitable because as ordinarily used they refer to the total heat energy of a spark, and this alone does not determine the ability of a spark to ignite a given gas mixture. To meet the difficulty the term "incendivity" has been proposed by the writer* to denote the property whereby a spark produces ignition of a combustible gas. The term is convenient for descriptive purposes, but no quantitative definition can yet be given. In the absence of a standard of incendivity sparks are ordinarily compared by measurements of their heat contents, except in special cases where they are referred to the energy supplied to the circuit which produces the sparks.

The principal investigations on the subject of spark ignition in internal combustion engines have hitherto been carried out by means of engine tests, the effects of different sparks being observed either on explosion diagrams or brake measurements. For the purpose of the investigation here recorded it was decided to explode in a chamber of constant volume weak quiescent gas mixtures at normal temperature and pressure, for the reason that the main facts can be more easily and definitely determined in this way than in engine tests, where the variable factors of the problem are less easily controlled. The sparking was in all cases at one position, this being approximately at the centre of the explosion chamber.

In carrying out the experiments a mixture was found by trial which produced explosions of moderate rapidity, as the indicator diagrams of such explosions can be more easily and accurately compared than those obtained by very rapid or very slow explosions. Using throughout a coal gas mixture of the same composition, sparks from the following sources were employed:—

(*a*) High-tension magneto.

(*b*) Induction coil with cam-operated make-and-break (primary supplied by 12-volt circuit).

(*c*) Induction coil with vibratory make-and-break (primary supplied by 4-volt circuit); 200 vibrations per second.

(*d*) Lodge condenser apparatus, vibratory make-and-break (primary supplied by 8-volt circuit); 70 vibrations per second.

The above are the principal types of apparatus used in practice. The heat contents of the sparks measured by means of the author's thermal balance were as follow:—

(*a*) 0.01 joules per spark at 120 r.p.m.
0.03 joules per spark at 1,000 r.p.m.
(*b*) 0.02 joules per spark at 80 r.p.m.
0.0018 joules per spark at 1,000 r.p.m.
(*c*) 0.0005 joules per spark.
(*d*) 0.026 joules per spark.

In all cases the diagrams were identical, both as regards the rate of combustion and the maximum pressure. From this it is evident that provided a spark is capable of producing ignition, increase of incendivity has no effect upon the power developed in the engine. This result confirms what has previously been ascertained from engine tests. The fact has not yet, however, met with general acceptance among engineers.

Having regard to the foregoing, the question arises: What ground is there for the belief that engine power is affected by the incendivity or so-called strength of the igniting spark? The experience is common among users of internal combustion engines that an increased spark sometimes results in improved operation of an engine, particularly when weak explosive mixtures are employed. The answer is to be found in the fact that an explosive gas mixture requires for its ignition a spark having not less than a certain incendivity, and the latter varies with the nature and proportions of the mixture. When the proportions of the mixture are at or near the upper or lower limits beyond which ignition is impossible the required incendivity is high. But as the proportions approach that of maximum explosibility the required incendivity rapidly diminishes. Hence for a given gas mixture a certain minimum incendivity is necessary in the spark. If the incendivity is near the limit a diminution in the explosibility of the mixture may result in no ignition, or only intermittent ignition. This can be rectified by employing a spark of higher incendivity, providing a greater margin for gas variations. In a petrol engine, particularly when running at slow speed, weak mixtures requiring strong sparks for their ignition are often obtained, and when the ignition system is insufficient to provide suitable sparks defective operation of the engine ensues. On replacing the ignition system by another producing stronger sparks the engine works satisfactorily. Arguing from this, the user concludes that the better spark has increased the power of his engine by increasing the rate of ignition or the maximum pressure, whereas actually it has only eliminated misfires.

From the practical standpoint the facts relating to "single point" spark ignition in internal combustion engines are comprised by the statements (1) that provided a given spark is sufficient to produce ignition any increase of incendivity does not affect the power obtainable from the explosion, and (2) that as the mixture passes from the proportion of maximum explosibility towards the higher and lower limits the required incendivity of the spark increases.

An outstanding and as yet unsolved problem in connection with ignition apparatus for internal combustion engines is that of defining the least spark required to produce ignition of a specified gas mixture, and with this problem is associated in general that of spark measurement. In the absence of an established theory of ignition any attempt to define a spark must necessarily be tentative, but some satisfactory temporary expedient is not impossible. Obviously the procedure of defining a spark in terms of the current in some part of the apparatus used for producing the spark is highly unsatisfactory, because sparks defined in this way are not comparable when produced by different apparatus. Any satisfactory method of spark measurement must involve nothing more than the spark. The most obvious and up to the present best developed method is the thermal one. In this it is usual to heat a quantity of gas by a succession of sparks until a steady state is reached, that is, the heat imparted to the gas is equal to the heat lost by the container. The average heating effect of the sparks can then be calculated and the heat content expressed in joules per spark. At first sight it would appear that the incendivity of a spark could be expressed as a function of the heat content, and if this were possible sparks could for practical purposes be defined in terms of joules per spark. There are, however, two facts which limit the usefulness of the thermal method. The first is that incendivity does not depend upon heat alone, but apparently on heat jointly with temperature, and the other that ignition seems to be the result of a cumulative action which can be set up by a succession of sparks when a single spark fails.

It is a matter of simple experimental proof that heat alone does not determine the incendivity of a spark. Using the same source of energy, say a magneto, two different types of sparks can be obtained, one by using the magneto normally and the other by connecting a condenser across the spark gap. The latter is contained in an explosion chamber which is filled with a weak gas mixture, and the magneto is adjusted so that working normally it produces a spark which will not ignite the gas. A condenser of suitable capacity is then attached across the gap, and by means of the resulting spark the gas may be exploded immediately. On measuring the thermal contents of the sparks it is found that the heat contained in the normal magneto spark is not less than that obtained with the condenser, and if a poor condenser is used it may be as much as 100 per cent. more, as in one set of experiments carried out by the author. Yet the spark containing more heat failed to produce ignition where the other succeeded. The only apparent difference was the temperature. It might be suggested also that the duration was different, and the shorter duration of the condenser spark caused it to be accompanied by greater mechanical violence. But for this there is no experimental evidence. Both sparks are oscillatory, and the effective portion has apparently the same duration in both cases. It follows, therefore, that incendivity is not a function of heat only, but of heat and temperature. And as the heat-measuring instrument accounts only for total heat, the measurement of joules per spark is only useful for comparing sparks produced by similar apparatus.

The second fact, that ignition appears to be the result of a cumulative action, is of less practical importance in connection with ignition apparatus for internal combustion engines, seeing that single sparks are now more generally used. But for purely theoretical work the fact is of importance. Using a magneto provided with a variable resistance in its primary circuit to permit large variations of the spark in the secondary circuit, and employing a needle point spark gap, very small sparks can be obtained. Keeping the gas mixture constant and varying only the speed or the primary current of the machine, it was found possible to arrange a condition in which the gas would never ignite with the first spark, and only after a number of sparks had been passed through could ignition be produced. Owing to the extreme difficulty of insuring perfect uniformity of conditions (a trouble which is common in work of this kind), the results were not sufficiently regular to permit of a quantitative deduction, but the persistence of the phenomenon was such at all times that only one conclusion was possible, namely, that succeeding sparks produced a progressive change in the gas which finally resulted in ignition, in other words, the ignition was the result of a cumulative action. The pre-ignition period could be shortened by increasing the strength of the spark (viz., by increasing the speed or the primary current), or by adding a condenser across the spark gap. The largest pre-ignition period noticed was about 2 seconds with the magneto running at 5 r.p.m. In a previous investigation* using low tension sparks the author observed a similar effect. The results obtained with the less active sparks were more regular and the pre-ignition interval was longer. Having regard to the foregoing, the difficulty of defining the least igniting spark for a given gas is apparent, but, as previously stated, where under practical conditions only one spark (or a plurality of simultaneous sparks) is used for igniting an explosive charge the difficulty disappears.

The trend of scientific opinion concerning spark ignition is that the action is ionic. It is not suggested that the heat of the spark is unrelated to the process of ignition, but that the thermal and ionic conditions are intimately connected. A natural alternative, if not a substitute, for a thermal instrument for measuring incendivity is the electroscope. The application of the latter for this purpose is not easy, because a number of arbitrary conditions, such as the shape and position of the spark gap relatively to the charged surfaces, and also the magnitude of the charge itself, have apparently to be stipulated before measurements can be usefully compared. Nevertheless the electroscope appears to contain useful possibilities in this connection. It is a matter of simple experimental

* "Notes on the Ignition of Explosive Gas Mixtures by Electric Sparks." Vol. 54, No 254, Journal of the Institution of Electrical Engineers.

* "Notes on the Ignition of Explosive Gas Mixtures by Electric Sparks." Vol. 54, No. 254, Journal of the Institution of Electrical Engineers.

MACHINE SHOPS OF THE LONDON AND SOUTH-WESTERN RAILWAY, EASTLEIGH.

MR. R. W. URIE, M.I.MECH.E., LOCOMOTIVE ENGINEER.

(*For Description, see opposite Page.*)

Fig. 29.

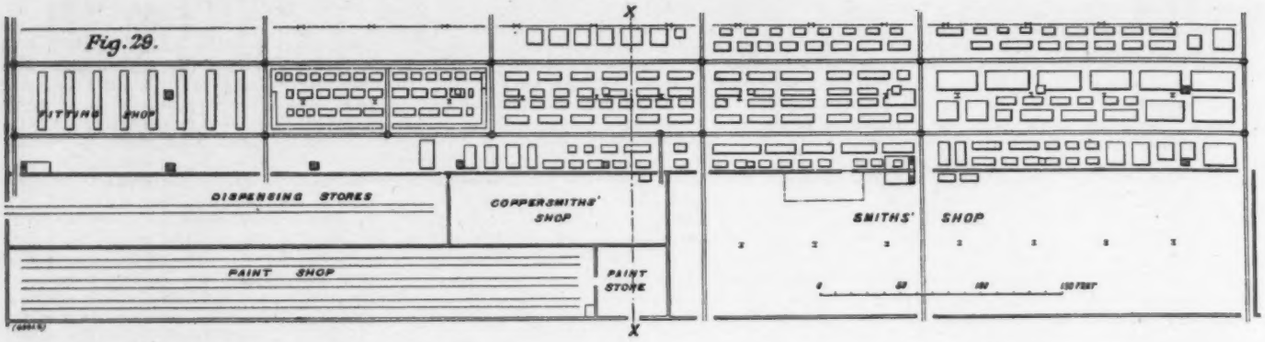


Fig. 30.

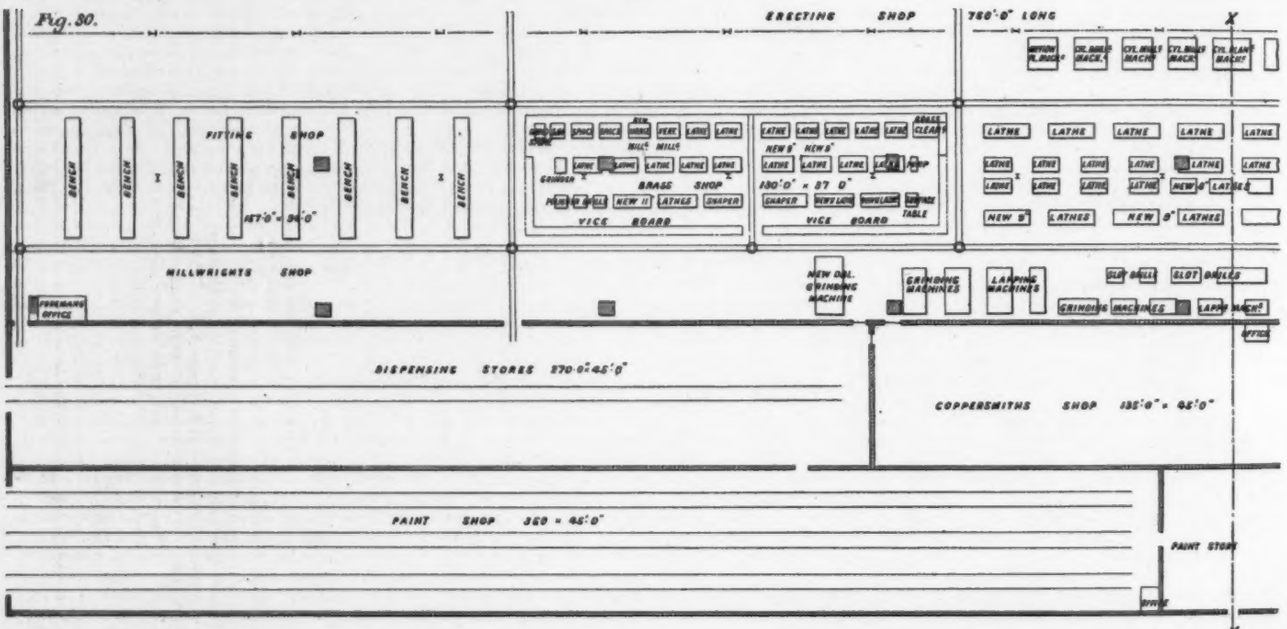
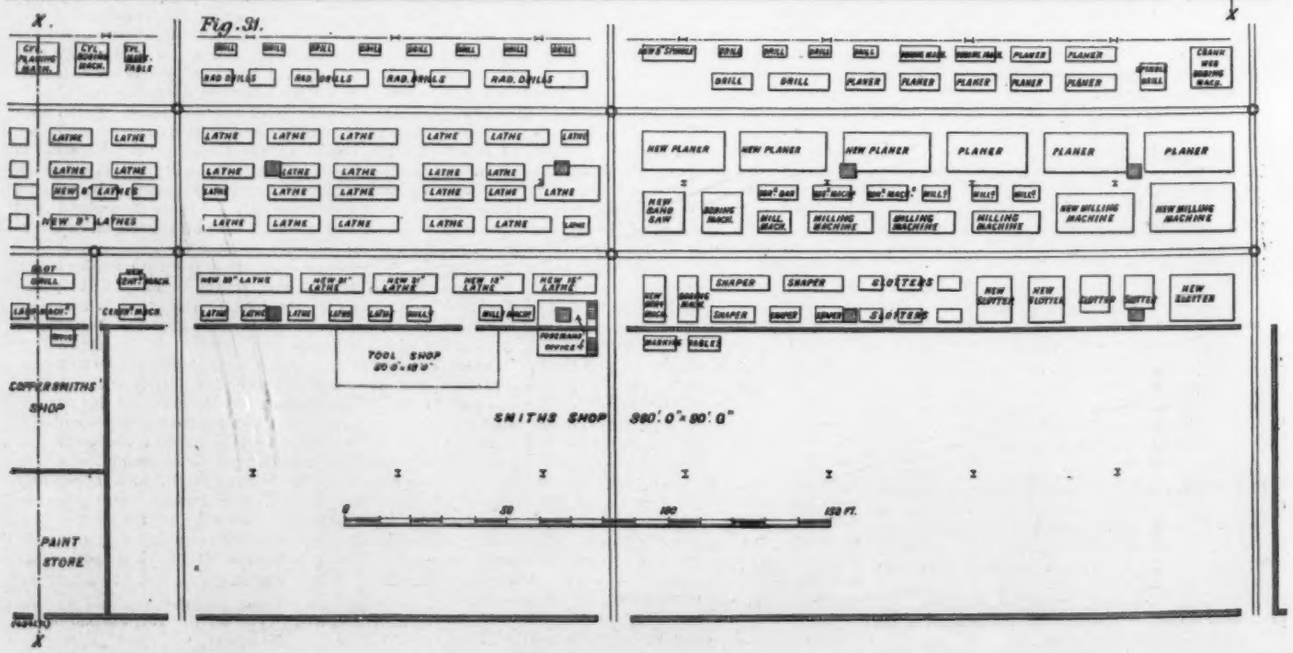


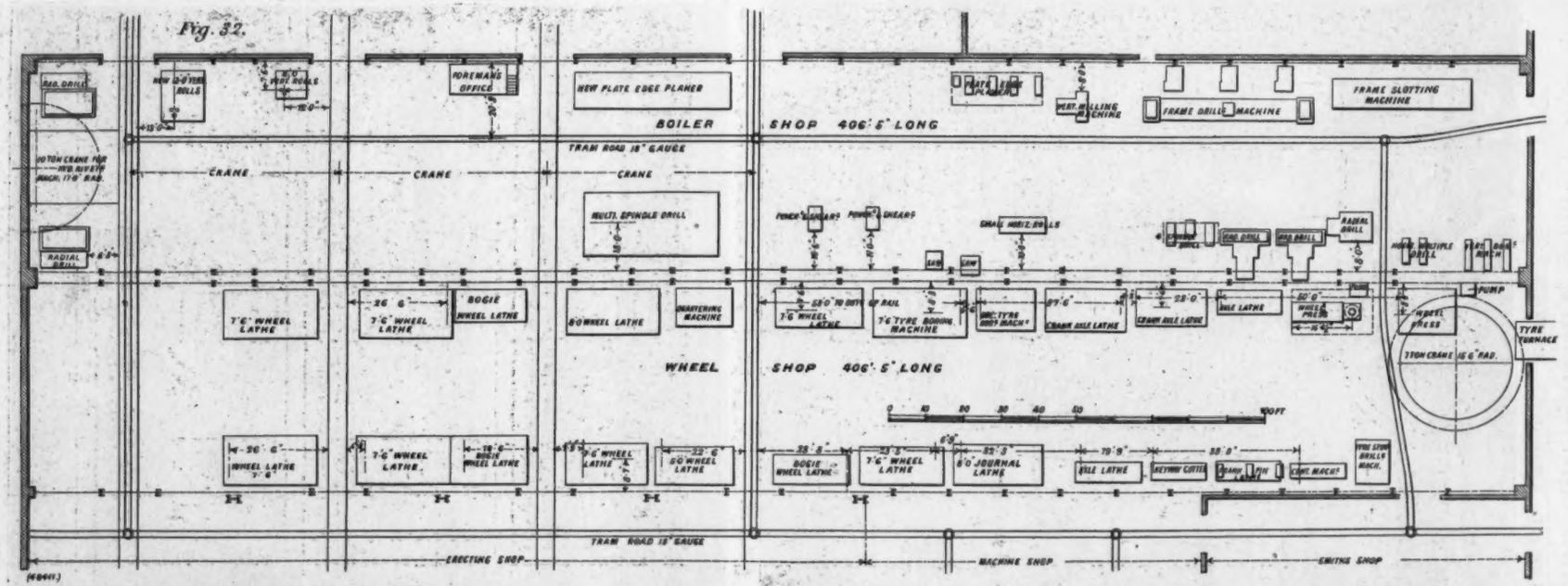
Fig. 31.



BOILER SHOP AND WHEEL SHOP AT THE LONDON AND SOUTH-WESTERN RAILWAY WORKS, EASTLEIGH.

MR. R. W. URIE, M.I.MECH.E., LOCOMOTIVE ENGINEER.

Fig. 32.



verification that the sparks of a condenser produce a larger discharge per spark than do sparks obtained when the condenser is removed, although the heat content of the latter may be the same or even greater than that of the former.

THE ARRANGEMENT OF MACHINE SHOPS.—No. VI.

By Joseph Horner.

Railway shops, in regard to their mammoth proportions, are only equalled by the marine and ordnance factories. Their products are specialised absolutely, and the separate departments are so vast that they are accommodated in distinct buildings or in separate bays of large buildings. The machines of a kind form very large groups—dozens, scores, exactly alike, disposed in rows, as wheel lathes, tyre lathes, axle lathes, cylinder-boring machines, crank-turning lathes, and so on. The vistas are vast, and the general aspect of some sections is that of monotonous repetition of similar machines and of absolutely identical operations, most notably in the wheel department. The conditions which exist in the railway shops are not those of machines of different kinds disposed adjacent to facilitate consecutive operations on a piece, but machines of one class are grouped in order to deal with an immense output of hundreds of pieces all exactly alike. The lathes—using the term in the most comprehensive sense—predominate, and after these the drilling and boring machines follow in numerical importance. Heavy tools greatly outnumber the light ones in the general machine shops, from which the brass-finishing department is, of course, excluded. This is always a very extensive section in a locomotive works and is kept wholly distinct from the heavy machine shop where iron and steel articles are tooled. The boiler machine shop is another special department equipped with tools for dealing with plates, comprising slotters, planers and drills chiefly. The repairing shops are entirely separate, again, from the manufacturing ones, and the entire wagon-building works is distinct from the locomotive department.

A modern railway works, therefore, is an organisation which is almost unique among factories, vast, diverse, homogeneous, a little kingdom under the control of the chief mechanical engineer, who holds and directs the operations of thousands of machines and of workpeople. The drawings and photographs reproduced on the present page and pages 428, 430, and 431 in illustration of this article are those of the shops of the London and South-Western Railway at Eastleigh, situated a few miles north of Southampton, and for them we are indebted to Mr. R. W. Urie, M.I.Mech.E., the locomotive engineer of the railway. These works were completed about six years ago, having been laid out and erected in place of the old shops at Nine Elms, the condition of which, congested with goods traffic, rendered a migration of the entire locomotive department unavoidable. The migration afforded an opportunity, almost unique in British railway works, of planning the shops anew in harmony with present-day ideas. Not only are the works laid out in parallel lines, with the shops in parallel or at right angles, but all are connected with railway sidings, and large areas are left for future extensions. Naturally the total area of the entire works much exceeds that of the machine shops proper here illustrated, but we are only concerned with these. The principal machine shop occupies two bays running parallel with each other and with similar bays adjacent, which comprise the erecting shop, provided with a continuous erecting pit, and one parallel with it devoted to boiler repairs. The machine shop shown in plan by Figs. 29 to 31, on page 428, is 765 ft. in length, with a total width of 90 ft. across the two bays. Within its area the brass finisher's department is included. The fitting and millwright's shops occupy the western end. Parallel with it run, as seen in the plan, others with inter-communications, the smith's, the coppersmith's, the paint shops, and a dispensing store. Fig. 29 is a general plan of the machine shop to a small scale. Figs. 30 and 31 illustrate the same shop to an enlarged scale, with the names of the machines and areas inserted. By comparing these enlarged views with the smaller plan a clear idea of the lay-out can be gathered.

The other machine shops illustrated are the wheel and the boiler shop, both being shown by the plan, Fig. 32, annexed. These are disposed at right angles with the large machine buildings, occupying the east end of the block, the power-house being adjacent. These two shops each measure 406 ft. 5 in. long. The wheel shop is 59 ft. 3 in. wide, and the boiler shop 58 ft. 3 in. wide. These also are in connection with the smithy.

The plan views of the principal machine shop (Figs. 29 to 31) may be compared with the photographs, Figs. 33 and 34, page 430. The latter are taken from the right-hand end of Figs. 29 and 31, and give fine perspective views. The machines seen in the foreground in Fig. 33 are the crank-web boring machine on the right, and the first of a long row of planers on the left. In Fig. 34 milling machines are seen on the right, and the traversing-head slotters to the left.

The grouping of the machine tools according to classes is to be observed. Generally the heavier tools are located at the entrance end, to the right, where the heaviest planers, slotters and milling machines are located. The work progresses towards the fitter's department at the opposite end of the long building, the heavier lathes preceding the lighter ones. The drilling machines and the grinding machines are arranged parallel with the

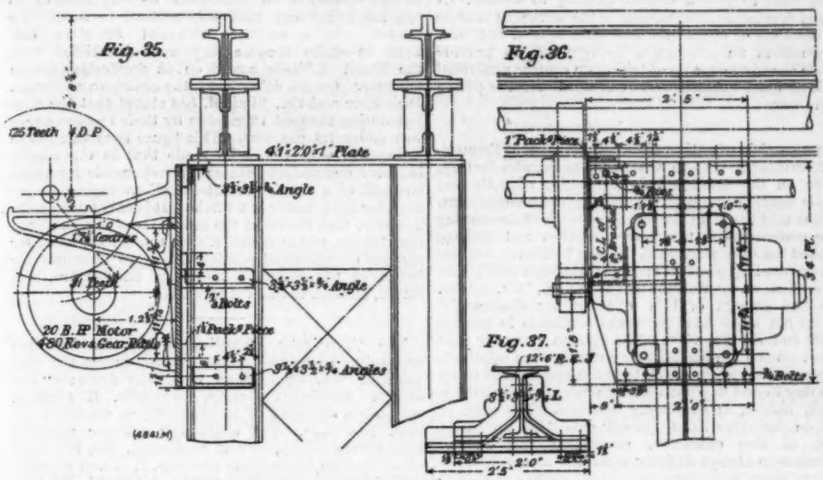
PRINCIPAL MACHINE SHOP; L. AND S.-W. RAILWAY WORKS, EASTLEIGH.

MR. R. W. URIE, M.I.MECH.E., LOCOMOTIVE ENGINEER.

FIG. 33.

FIG. 34.

L. AND S.-W. RAILWAY WORKS, EASTLEIGH.



FIGS. 35 AND 36. METHOD OF MOUNTING MOTORS AND CONNECTIONS TO LINE SHAFTING.

light lathes. Beyond lies the brass shop, the last stage before the fitting department is reached. All these are in communication with the erecting shop on the north side.

The wheel and boiler shops adjacent are shown by Fig. 32, flanking at right angles, as already stated, the large machine shop, the smithy, and the erecting shop, and in communication with them. The inscriptions on the various lathes, boring machines and drills will convey a general idea of the character of the machines installed for wheel, axle and tyre work. At the right-hand a tyre furnace and a wheel press are served by a revolving crane. The boiler shop contains the usual rolls, plate-edge planers, frame-plate slotters, punching and shearing machines and multiple drills.

Belt drives are employed for most of the machines, exceptions occurring in several of the heaviest designs, which are motor-driven, the usual practice now adopted. The line shafting is carried on brackets bolted to the main columns. The countershafts are slung from deals bolted to the underside of the light lattice-braced girders which connect and tie the longitudinal girders on the columns. These and other details are shown very well in the photographs.

The large group system of driving is adopted, the line shafts being driven by motors of from 20 to 50 brake horse-power. These run uniformly at 480 r.p.m., with gear reductions of 4 to 1 to the line shafts. The method of erecting and supporting the motors on brackets attached to the columns is shown by Figs. 35 and 36 annexed, while Fig. 37 is a detail of the angle iron brackets bolted to the columns.

The roof is of the ridge design, with two continuous skylights running parallel on each slope. The walls are blank. Arc lamps provide artificial light, but these are now being changed to ½-watt metallic filament lamps, an alteration which will be completed by the winter.

It will be noticed that the trolly tracks shown on the drawings do not appear in the photographs. The explanation is that the latter were taken before the tracks were laid down. The crane installation is not shown in either illustration, being of subsequent date. It comprises various jib cranes, provided for all the heavy machines. The fitting shop is equipped with overhead pneumatic hoists attached to runways.

THE WATER POWERS OF CANADA.

BY the issue of a series of reports,* compiled by expert authorities from official sources and admirably adapted to attract notice, Canada wisely directs attention to the diverse fields for enterprise and the many opportunities for the investment of capital that the country has to offer. Since the most valuable resources in a country are those which afford the means of producing cheap power, and, owing to the development of hydro-electric plants, falling water occupies a prominent place among these, several of these reports refer to the natural sources of energy in the lakes and rivers, and the plans for making the vast water powers of the country valuable to the community. As detailed reference has been made in these columns to the more important of these reports, only a brief reference will be made to the very interesting publication giving a general outline of the water resources, available and developed, throughout the whole of the country from British Columbia to Nova Scotia.

From this compilation we learn that within the last 20 years the streams and falls of Canada have been made to supply a total of 1,713,000 h.p., a form and an amount of energy that we can hardly apprehend, since England has not been richly endowed with similar resources. Ontario, by reason of the rapid advance in the art of high-voltage transmission, that enables her to scatter far and wide the immense store of energy in Niagara, leads the way, sending through the cities and villages more than three-quarters of a million of horse-power, while Saskatchewan, whose wealth lies rather in her soil than in her rivers, hangs behind with a modest 45 h.p. These figures indicate vaguely the varied distribution of this valuable asset, due mainly to geologic and topographic conditions.

The prairie provinces, occupying the site of an ancient sea, of which they formed the bed in Mesozoic times, do not possess that great difference of surface level within moderate distances that is favourable for the production of a large "head" and hydraulic development. The small amount of annual precipitation in a large part of the country is another unfavourable factor. Notwithstanding these drawbacks, which have made the three central provinces fall behind in the race for hydraulic power, eventually some 2,500,000 h.p. will be available, but for some time to come Alberta and Manitoba are likely to be fed by the neighbouring provinces on the west and east respectively, but Saskatchewan will probably suffer by lying outside the limits of economical transmission.

British Columbia, on the other hand, possesses very favourable opportunities, and naturally has availed herself of them. Notwithstanding her comparatively recent colonisation, the aggregate horse-power distributed among her scattered inhabitants is more than 250,000. The Rocky Mountains on the east, with the parallel range of the Selkirks, offer precisely those conditions that favour development. The former range consists of the upturned edges of the strata that underlie the great North-West plain, and the latter, representing an earlier upheaval, divide themselves into a threefold system that presents great ruggedness of surface. Further, the plateau between the mountains and the coast, forming huge grazing lands of immense value, has been so deeply intersected and eroded by lake and river systems, that in many places the surface resembles the mountainous regions, giving rise to gorges and fissures through which flows the water, drawn from an ample precipitation, in a form that can be easily utilised by suitably constructed storage reservoirs and dams. To what extent British Columbia can add to its existing water power it is difficult to forecast, owing to much of the country being unpopulated and unexplored, but the Fraser River alone with its tributaries, within easy working distance of Vancouver, will prove an immense storehouse. The same natural forces that have given the western province a large water supply in a form admirably adapted for power development have also richly endowed the country with minerals and ores. This combination is happy, for electro-metallurgy, to whose importance the country is fully alive, will give to these ores enormous commerical value, and her busy factories, provided with an abundant supply of cheap power, should challenge the admiration of the world. Add to these advantages the benefits accruing from three trunk lines of railways bringing to her rising ports the products of a Continent, and it is difficult to set a limit to the possible wealth and progress of the far-distant colony that overlooks and commands the Northern Pacific, whose influence in shifting the trade routes of the world is already making itself felt in the eastern hemisphere.

If we turn to the eastern side of the Continent, to Quebec, stretching northwards to the inhospitable shores of Labrador, and to the maritime provinces generally, the same abundant resources exist, calling for energetic judiciously co-ordinated development. Quebec has already utilised some 500,000 h.p., but this quantity only touches the fringe of her latent stores, that on a moderate estimate could furnish forth ten times the amount without any expensive regulation of the rivers by storage reservoirs. Much of this undeveloped power is at present beyond the reach of active markets and can await development. But where, as in the Three Rivers District, there is inquiry for electrical energy, Quebec is equal to the emergency. On the St. Maurice River a dam is being built at a cost of 1,500,000 dols., with the view of effecting storage that will ensure power plants within reach a constant and steady supply of water at all seasons of the year. The water level in a number of lake will be permanently raised, and a good deal of unproductive territory flooded. The total area of the reservoir will amount to 300 sq. miles, rather more than that of the county of Middlesex: such are the magnificent schemes that can be executed in a new country. In the maritime provinces of Nova Scotia, New Brunswick and Prince Edward Island the employment of water power is on a moderate scale and has been regarded as secondary in importance to the mineral and agricultural wealth of the provinces. Where, however, minerals as iron, gold and coal are found, electric energy will be needed for many purposes. The rival sources of power supplied by coal and water are not necessarily antagonistic, but can be advantageously employed in co-operation. The desire for progress on modern lines by utilising the latter is shown by the acceptance of a scheme for installing an 80,000-h.p. plant, under a head of 140 ft., at Grand Falls, on the St. John's River. Other sites are available and likely to be utilised at an early date.

In a few years it is probable that 8,000,000 h.p. will be available in Canada within market range, and will no doubt find ready absorption, for opportunities of new application arise with increased supply. The near future will see the greatest progress in electro-chemistry and electro-metallurgy, in long-distance traction applied to railways, and in the distribution of electricity in rural districts. In another direction the problem of the production of artificial fertilisers will demand serious attention. There will probably be not less than 200,000,000 acres of arable land within the Dominion under cultivation, and each acre will demand annually on an

* *Water Powers of Canada: Being a reprint of five monographs covering the water-power situation in Canada, prepared for distribution in connection with the exhibit of the Dominion Water Power Branch in the Canadian Pavilion at the Panama-Pacific Exposition, San Francisco, 1915.* Ottawa: Published by Authority of the Minister of the Interior.

average 100 lb. of nitrates, or about 10,000,000 tons in the aggregate. The efficiency of electric production of nitrates is low, and in the future 5 tons per horse-power year would probably measure the highest efficiency. The horse-power required to meet such a yearly demand would therefore be 2,000,000, a staggering figure, but, however great, we believe the energy of the Canadians will know how to cope with it.

INDUSTRIAL NOTES.

An official report dealing with the third and fourth quarter of 1915 and the first and second of 1916 as regards mining wages in the different Prussian mining districts shows that wages on the whole have continued to increase. The wages averaged as under, for the various districts during the four quarters mentioned above, per hand :—

—	1915.		1916.	
	3rd Quarter.	4th Quarter.	1st Quarter.	2nd Quarter.
	Marks.	Marks.	Marks.	Marks.
Upper Silesia.. ..	332	331	346	348
Nether Silesia.. ..	325	331	331	348
Dortmund district ..	502	500	521	525
Halle lignite district	326	324	335	333

Attention is drawn to the fact that the quarters preceding those referred to above also witnessed a rise in wages.

The Secretary of the Office of the Labour Adviser to H.M. Government forwards the following for publication :—"A conference of representatives of ski led trades connected with the engineering and shipbuilding industries was held on the 27th ult. at the Central Hall, Westminster. The Rt. Hon. Arthur Henderson, M.P., who presided, said the conference was one of several to be held in connection with the Office of the Labour Adviser, at the request of the Man-Power Distribution Board, to consider their proposal that dilution should be extended to private and commercial work in controlled and non-controlled establishments. Hitherto such dilution as had been secured had been limited, speaking generally, to war work. It was now essential that substitution and dilution should become much more general. This was called for by the urgent need of securing for general military service all the men available and eligible up to the limits of the Military Service Acts, by the great demands for skilled workmen for the technical units of the Army and for the production of munitions and ships, and by the vital importance of continuing our export trade in order to maintain the financial strength of the British Empire and our Allies. The present unsatisfied demands of the technical units of the Army and of munitions, skilled and unskilled, were 160,000, and the skilled requirements alone were 32,000. It was the desire of the Government, as recently stated by the Prime Minister to the engineering trades deputation, that the skill of the workmen should be utilised in the best interests of the nation. This could not be secured without further dilution, and this conference had been called to consider the best means of securing this. After a full discussion the conference decided to adjourn in order to obtain from the Man-Power Distribution Board information as to the best means of preventing the enlistment of skilled men, which still continues, and of securing better methods of debadging, and to await a report as to the local machinery contemplated by the Man-Power Board for giving effect to dilution on private and commercial work."

In this connection it may be noted that the authorities are anxious greatly to increase the number of women employed. This is, of course, already considerable, between 17,000 and 18,000 being employed in one shell-filling factory which was visited last week by Lord French. In other departments of munitions making, however, comparatively few women are as yet employed, although 800 to 1,000 additional hands per week are required. To increase the numbers available special training schools have been established in various industrial areas. In some of the provincial towns there is, it appears, already a waiting list, but in London there are, it would seem, still many vacancies in the schools at Brixton, Shoreditch and other training centres. It is intended to devote one of the London schools specially to the training of girls in the light welding and other metal work required in aeroplane building. In Newcastle-on-Tyne rapid progress is reported at the women's training school opened in Rutherford College, where over 1,000 have applied for instruction. The period of training here extends over six to eight weeks. The large schools established at Birmingham in 1915, mainly with a view to training male workers, are now being used to give a similar training to women. A special feature at Birmingham is the advanced courses for students of either sex who show special aptitude. At Sheffield an attempt is being made to provide female chemists capable of taking up routine analytical work at blast furnaces and steel works for the period of the war.

In an article recently published, Mr. Arnold Bennett, in describing a visit to a national projectiles factory, dwells on the characteristic differences of male and female workers as reported to him by the management. He was told that "in the briefer operations demanding close concentration the women rivalled and perhaps excelled the men, whereas in the long tedious operations (not demanding physical strength) the men easily beat the women, whose attitude was apt to be, 'Oh, bother, I've had enough of this exasperating dullness.'" We do not know how far works managers in general would endorse this view. The opinion generally held is that women are particularly enamoured of relatively simple routine work, which they are prepared to go on with day in and day out without change of occupation, which, indeed, is commonly resented. The man or boy, on the other hand, quickly gets "fed up" with work of this character, resembling the ancient Athenians in always desiring some new thing.

The Minister of Munitions has established a Central Clearing House Organisation in the Ministry for the purpose of tracing and registering machinery which is idle or about to become idle. The Organisation will endeavour : (*a*) To ensure that contracts placed by the Ministry are directed towards any unoccupied manufacturing capacity which might exist in the country. (*b*) To place engineering contractors, who have suitable facilities for particular supplies, in touch with the Ministry and with other Government Departments requiring these supplies, and to help contractors who are able to undertake additional or more suitable work now or at a future date to maintain continuous employment of their machinery and labour. Manufacturers possessing idle resources and desiring to be placed in touch with Government contracting departments are invited to communicate with the Central Clearing House, Ministry of Munitions, 8-9, Northumberland-street, W.C., when further particulars will be sent.

The Minister of Munitions announces that he has made further orders under the Munitions of War Acts, 1915 and 1916, under which 74 additional establishments have been declared controlled establishments. The total number of controlled establishments under the Munitions of War Acts, 1915 and 1916, is now 4,390.

A conference on the position of our chemical industries after the war was held at the London Chamber of Commerce last week by a joint meeting of the four sectional committees directly concerned with that department of industry. There was a general agreement that the new situation must be met by new methods, and that if the conditions are found to require protection in particular cases the claim for this could not be met by arguments based on mere general principles. Academic economists declare that free imports necessarily reduce prices to the consumer, but this is only true so long as native firms continue to compete. If they retire from the contest, thus permitting a foreign monopoly, the consumer may find previous prices more than doubled. A notable instance of this was mentioned at the spring meeting of the Institute of Metals.

According to the *Iron and Steel Trade Circular* the total production of steel in Austria-Hungary during the present year will reach about 3,350,000 tons, as compared with 2,690,000 tons in 1915, 2,190,000 tons in 1914, and 2,790,000 tons in 1913. The output of all classes of iron and steel in the current year, it is stated, will exceed that of any previous year.

More industrial trouble is anticipated at the Mersey Docks, where the National Transport Federation are organising a movement against the employment of non-unionists. So far employers have refused to comply with the demand.

There have been many cases of lost or wasted time brought before the Munition Courts during the past week. As yet, however, steps are not being taken to debadge persistent offenders. The cause is, however, not always slackness. At the Birmingham tribunal, for example, a young workman of 23 was prosecuted for losing time, the reason being that though employed on munitions he was anxious to join the army and took this method to secure his release. In a northern shipyard 30 rivet lads went on strike because they were dissatisfied with the Board of Trade award on an application for an advance. On the other hand, the chairman of Messrs. Dick Kerr and Co., Limited, has stated that the time lost during the past 12 months by their Preston hands was under 1.4 per cent. This figure is of interest in connection with the claim made that in the mining industry unavoidable causes are responsible for about one-half of a total "absenteeism" averaging 10 per cent. for the country as a whole. It is only fair to note, however, that 28,000 of the most robust miners joined the Colours, and in South Wales, though the men, for reasons of industrial politics, demur to measures for increasing the output, a very large number are, it is stated, anxious to enlist if permitted.

The *Manchester Guardian* gives the following particulars as to the profits reaped during the past financial year by German munitions firms :—"The Kappel Machine Company, Chemnitz, it appears, proposes a dividend of 28 per cent., as against 5 per cent. last year. The company's pre-war products were textile machinery and appliances, but, like most other German engineering concerns, it is now engaged exclusively on munitions. The Vogtland Machine Works has a net profit of 100,500*l*., as against 78,500*l*. last year, and is paying 10 per cent., as against 6 per cent. The Mannesmann Tube Works, the largest makers of steel tubes in Europe, show a net profit of 849,500*l*., as against 406,000*l*. last year, and are paying 15 per cent., as against 10 per cent. The Vereinigte Königs und Laura Hütte, one of the leading coal and iron companies, is paying 10 per cent., as against 4 per cent. The Rombach Iron Works report a net profit of 256,000*l*., as against 159,000*l*., and are paying 8 per cent., as against 5 per cent. last year. The Dillinger Iron Company is again paying 18 per cent. The Augsburg-Nuremberg Machine Works, the principal makers of large gas engines in Germany, have a net profit of 290,000*l*., as against 140,000*l*. last year, and are paying 16 per cent., as against 8 per cent."

The *Birmingham Daily Post* reports that really good results are beginning to accrue—measured from the standpoint of national trade—from the virtual prohibition of motor imports and the encouragement of motor exports. The Board of Trade returns recently published reveal this very clearly. The returns show that the motor trade of the country is now proceeding on parallel lines to the general trade of the country, to the extent that exports are increasing and imports decreasing. This is an exact inversion of the position of affairs a year ago, when our exports of complete cars had fallen to 58,038*l*., as compared with 159,803*l*. in September, 1914, and our imports showed an astonishing rise to 386,764*l*. in September, 1915, from a mere 29,896*l*. a year previously. The latest figures show that we have now recovered practically all the ground lost in 1915, and are virtually where we were two years ago, our September, 1916, exports being 152,341*l*., the corresponding imports being only 38,391*l*. Should this state of affairs continue, the motor industry will be doing quite its fair share to adjust the present adverse trade balance. The exportation of British-built cars is specially encouraged by the Government not only because of its effect on trade balances, but on account of the fact that it enables—though, of course, only to a limited extent—British manufacturers to retain some hold on overseas markets that are in serious peril from American competition.

In his presidential address to the Birmingham Branch of the British Foundrymen's Association last Saturday, Mr. J. Shaw (Dudley) said the first thing that struck an American in visiting shops in this country was the large diversity of work done in the same foundry, and while this practice produced better moulders, it added to the cost of production compared with the costs in shops which confined themselves to fewer lines. Both American and German practice tended to specialisation in a few types of castings at a minimum cost, utilising every possible labour-saving device. In this country, as pioneers in the iron and steel trade, we laboured under the disadvantage of old and often obsolete plants. Of the 170 foundries in the Birmingham district very few were new and built on modern lines. Of the 36 fitting shops in Birmingham, only about 5 per cent. had railway sidings. Many were dark, badly ventilated, and deficient in crane power. Whether it was practicable to build fresh works in suitable places on modern lines was one of the questions employers would have to face. While many new fitting shops had been

built to meet the demands made by the war, very few foundries had been erected; the old ones had been adapted, and he was afraid the end of the war would find their trade in a position little better than it was before.

The National Union of Boot and Shoe Operatives is making strong efforts to have their industry excluded from the unemployment section of the National Insurance Act. The matter has gone to arbitration, the Union contending that their trade is not included in the list scheduled in the Act. This gives power to include leather manufactures, but the Union claim that this is an inadequate description of the trade where many other materials are used.

The quarterly meeting of the Coal Conciliation Board for England and North Wales was held in London last week, when the men's representatives made a request for a further increase in wages in view of the increased cost of living. The wages paid to the miners in the Conciliation Board area are at the maximum percentage under the new agreement, which is in force for a period of three years from May 1, 1915, and in addition a war bonus of 15½ per cent. is being paid under Mr. Asquith's settlement, to meet the high cost of living. Mr. Stephen Walsh, M.P., in presenting the men's case for an advance in wages, said the proposals for an increase to meet the higher cost of living were made as a request for consideration by coal-owners, and not as a demand, as there was a desire on the part of the men honourably to observe the obligations into which they had entered by their own signed agreement.

Mr. F. J. Jones said in reply that the coalowners' section of the Board recognised and appreciated the manner in which the men's proposal for an increase of wages had been presented, and promised that it should have proper consideration by the general body of coalowners in England and North Wales. It was only right to point out that there had been a very serious increase in the cost of pit timber and everything else required to work the collieries, and that many collieries were finding it exceedingly difficult to meet his increase in the cost of working.

There have been many reports during the week of attempts to settle a satisfactory working basis for industry after the war. Parliament has agreed that the trade unions shall have the right to insist on the establishment of the *status quo ante* when the present emergency ends. As, however, this would necessarily involve a recurrence to pre-war rates of pay, it is possible that the unions may agree to waive their claim to a re-establishment of output restrictions in return for a maintenance of existing rates of pay. No indication of any such spirit of mutual concession is, however, to be found in the proposals advanced by the Parliamentary Committee of the Trade Union Congress, in which the following demands are made:—

Membership of a trade union to be compulsory on all workers; compulsory 48 hours working week in every occupation; compulsory minimum wage of 30*s.* for all adult workers; no reduction of present wages, or increase in working hours; complete recognition by employers of trade unions, and of agreements entered into between the unions and employers' associations; State unemployment pay for men and women out of work; settlement by unions of conditions of women's labour after the war.

A really aggressive spirit was displayed at last week's meeting at Manchester of the Union of Co-operative Employees in Lancashire and Cheshire, where employers were accused of using the present time of stress to strengthen their position. As usual, no details were given, but the speaker continued that he could see no evidence of a change in relations between employers and employed as a result of the war.

The following statement appears in the *Glasgow Herald*:—"A movement is now on foot in one of the great staple industries of the country which, should it materialise and be a precedent for the other staple trades to follow, would go far to transform the whole face of our industrial life. It is nothing less than the formation of a National Industrial Council composed of representatives of employers and employed, which would find its field of action in aiding the common interest by focusing the combined energies on promoting the progressive development and welfare of the industry. The function of such a body would be neither judicial nor conciliatory, but instructional. Members of this Industrial Parliament would be equipped with special knowledge as to the needs of their industry, and they would find scope for their energies in such problems as the consideration of improved methods and organisation, the maintenance of discipline and output, the improvement of design and workmanship, the education of apprentices, prevention of unemployment, questions of wages and piece rates, and the prosecution of research and experiment. Combined action on these lines is now being considered by one of the great trade unions. Opinion is generally favourable to the idea, and it is confidently expected that the leaders will shortly approach the employers with a request for their co-operation.

STARTING DIESEL ENGINES WITH LOW COMPRESSION.

To the Editor of Engineering.

Sir,—With reference to my letter in your columns last week, I would ask you to allow me to correct an error in the expression there given for Diesel engine efficiencies, obtained in accordance with the assumptions made. The correct expression is

$$\eta = 1 - \frac{1}{r^{\gamma-1}} \cdot \left\{ \frac{2\left(x\rho^{\gamma}-1\right)}{\left(\gamma+1\right)\left(x-1\right)+\left(\rho-\frac{x}{\rho}\right)\left(\gamma-1\right)} \right\} \quad (1)$$

I find that this expression gives thermal efficiency values which diminish as x increases, so that it appears that the thermal efficiency does increase with diminishing load, and hence this expression corroborates the usual theory. Although it is true that experimental evidence can be adduced to support such theory, I am not convinced that such evidence is conclusive, and would beg the further hospitality of your columns in order to give my reasons at some length.

In the first place, the error made was due to the fact that, before working out the expression, I reasoned that since, with a given compression ratio, constant volume combustion gives higher thermal efficiency values than constant pressure combustion, it would follow that efficiencies should be greater the greater the slope of the combustion line. I was very much surprised to find out that, on closer investigation, under the conditions given in my last letter, such is not the case. If m, i.e., the slope of the combustion line, is taken as equal to infinity, it would seem that to all intents and purposes we have the constant volume cycle, and should, therefore, obtain the corresponding high efficiency value. It will be seen, however, that the reason for the discrepancy lies in the assumption of a constant value for ρ. I find that the correct condition to impose for the purposes of comparison is to assume combustion lines of varying slope, but with the same amount of oil injection or heat supply in each case. This condition evidently implies the constancy of the denominator in expression (1),

$$\text{or} \quad \left(\gamma+1\right)\left(x-1\right)+\left(\rho-\frac{x}{\rho}\right)\left(\gamma-1\right) = \text{constant}. \quad (2)$$

and this gives a relationship between x and ρ which must be observed in making fair comparisons. The following table gives values of ρ, x and η when $r = 13$, under the condition that $\rho = 2$ when $m = 0$:—

ρ	1	1.2	1.4	1.6	2	2.5	3
x	2.4	2.28	2.19	2.12	2	1.88	1.77
η	0.643	0.628	0.613	0.602	0.580	0.568	0.557

These values show that, with a given heat supply, the efficiency decreases with diminishing slope of combustion line. It would seem therefore that, if at the lighter loads the diminished fuel supply is unable to keep up the combustion line, the thermal efficiency, instead of increasing, would actually decrease. In any case it does not appear that any increase of thermal efficiency at low loads should be as great as it is represented to be in a number of published tests. I would here disclaim any desire to throw doubt on the validity of these experiments generally, but in common with many engineers I am somewhat sceptical regarding the quantitative value of indicator diagrams. As qualitative records they are invaluable, but seldom anything more.

I must apologise here for having intruded so much theory into the discussion. My only excuse is that Mr. Benton's question, which I have attempted to answer from the theoretical point of view, was one in which I was much interested some time ago.

Mr. Benton's explanation of the high efficiency of the Diesel engine is probably only partly true. To my mind the reason lies mainly in its high expansion ratio, a factor which is too little considered when comparing the performances of internal combustion engines of different types.

I am, yours, &c.,

Wm. J. Walker.

"Ridgmont," Aircraft Esplanade, Farnborough, Hants.
October 28, 1916.

To the Editor of Engineering.

Sir,—The second letter by Mr. Benton on the above subject, published in your issue of October 27, is as full of interesting matter as was his first letter, and I agree with most of his conclusions.

I would, however, point out that Mr. Benton in his second letter introduces additional factors with which I did not deal either in my letter published in your issue of October 20 or in my short paper to the British Association. In both of these I dealt only with the compression part of the cycle, and as the air is non-luminous during compression the loss of heat from it is due, almost entirely, to convection and exceedingly little to radiation. During combustion the gas is luminous, and during this period the conditions are probably reversed and the rate of transfer of energy from the gas to the cylinder walls by radiation is probably, in most cases, greater than the rate of transfer by convection.

Yours faithfully,

W. H. Watkinson.

Walker Engineering Laboratories. Harrison-Hughes Engineering Laboratories. October 31, 1916.

New Nitrogen Works.—A new company with a large capital has been formed for the manufacture of nitric acid and other chemical products in Sweden. It has entered upon a contract with the Royal Waterfalls Board for the supply of electric energy, 12,000 kw., from the Trollhättan power station, and the works will be erected on the area reserved for industrial installations at Trollhättan. The annual capacity will be some 7,000 tons concentrated nitric acid, with nitrates as an auxiliary product. The new company will adopt the Birkeland-Eyde method, for which rights have been secured for Sweden. The work is being pushed ahead with all speed, and the works are guaranteed to be ready this year. The Swedish explosives industry and the large Grängesberg mining company are represented on the board.

French Railways.—There has been a satisfactory recovery in French railway traffic—that is, a satisfactory recovery in the earnings of the lines still in French working. Two important companies—the Northern of France and the Eastern of France—are still practically, however, in German hands. Subject to this remark, we may note that the earnings of the French State lines, the Western of France, the Paris, Lyons and Mediterranean, the Paris and Orleans, and the Southern of France, amounted in August to 5,350,320*l.*, as compared with 4,807,840*l.* in August, 1915, and 3,100,080*l.* in August, 1914. The increase upon the French State lines was 15,840*l.*; upon the Western of France, 159,480*l.*; upon the Paris, Lyons and Mediterranean, 219,360*l.*; upon the Paris and Orleans, 115,480*l.*; and upon the Southern of France, 32,320*l.* The recovery from the depression of August, 1914, was much more decided.

Vancouver.—The construction of a new pier at Vancouver is to be undertaken by the Canadian Pacific Railway Company. In addition to its main docks, it has now Pier A, at which trans-Pacific boats dock, and Pier D, at the end of Granville-street or Burrard Inlet, which is used by Victoria and Seattle boats. The new pier will be known as Pier B. It will run 800 ft. out into the water at the end of Granville-street, and it will be used for both local and trans-Pacific traffic. The wharf will be larger and better than any other at Vancouver, and it will have the most modern apparatus and improved equipment to expedite and facilitate the loading and discharging of vessels. It was proposed a short time since to proceed with the construction of Pier C, and soundings were made, but the plans have been changed in view of what are believed to be the greater demands of the future.

The German Explosives Industry.—Within the German explosives industry the impending all-round increase of capital is attracting much attention. The united Cologne-Rottereiler Powder Works are about to increase the capital from 16,500,000 marks to 33,000,000 marks, and the old shareholders are to have the new stock at par. The Rhenish-Westphalian Explosives Company, which is closely related to the former, has decided likewise to double its capital, from 6,500,000 marks to 13,000,000 marks, and the Siegen Dynamite Company, in Cologne, which is under the management of the company just mentioned, is also doubling its capital, from 300,000 marks to 600,000 marks. The Dynamite Company, in Hamburg, the old Nobel concern, which in the German general Kartell constitutes the opposite pole, has a capital of 36,000,000 marks. This latter company only paid 20 per cent. for 1915, whilst the Cologne-Rottereiler was able to pay 35 per cent., on account of its position in the Kartell, in spite of its smaller capital.

The German Cement Industry.—So far the negotiations about an all-Germany cement union have proved unavailing, the principal stumbling block being the allotment question. The aggregate allotment of all the works in the contemplated sectional union had been put at 45,200,000 barrels, which were to be apportioned as follows:—South Germany, 11,000,000 barrels; North Germany, 24,000,000 barrels; Rhineland-Westphalia, 10,200,000 barrels. The Rhenish-Westphalian cement works have repeatedly argued that the above allotment only represented about half their capacity or not even that, inasmuch as the total capacity, including some outside works, which were to be included, amounted to some 26,000,000 barrels. In the current Bochum Union, 21,300,000 barrels are allotted, arising from extensions of old works and new installations. Owing to over production and foreign competition, facilitated by cheap waterways, the selling conditions of the West German cement industry have been exceedingly bad of late years, so that only a small portion of the allotted quantities was disposed of. The Bochum Union demanded an additional allotment within the duration of the new agreement (to 1925) of 1 per cent. of the aggregate allotment, a demand which has been opposed by the other groups. Whether fresh attempts will be made to bring about the all-Germany union and thereby avoid the looming coercive syndicate, remains to be seen; in the meantime the works have grace till the end of the year.

TWIN-SCREW MOTOR-SHIP "ABELIA," OF THE FLOWER MOTOR-SHIP COMPANY.

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, WALKER-ON-TYNE.

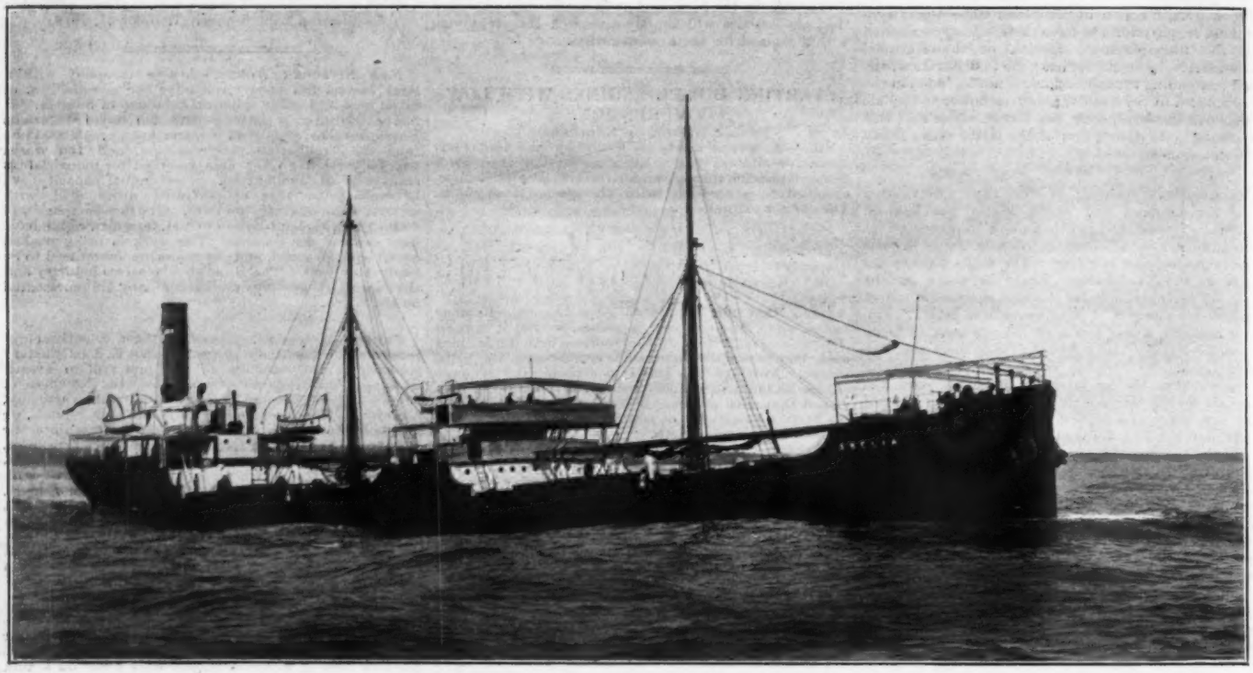


FIG. 11. THE "ABELIA" LOADED.

THE TWIN-SCREW MOTOR-SHIP "ABELIA."

(*Concluded from page* 379.)

WE now conclude the publication of our illustrations of the twin-screw motor-ship Abelia by reproducing on Plate XXXIV the drawings of the general arrangement of the machinery, on the present page a view of the ship fully loaded, ready for sea, and on the opposite page a longitudinal section of the ship and deck plans.

Regarding the main propelling engines, which are of the Diesel type, adapted, as described in our preceding article, as closely as possible to marine steam-engine practice, we may first direct attention to the fact (shown by Fig. 5 of Plate XXXIV) that the engine seats rest directly on the top of the tank. Another observable fact is that there are on the extreme port and starboard sides, at the forward end of the engine room, as shown in Figs. 5, 6 and 8, drain tanks for containing the cooling water for the pistons, while there is also, close to the forward bulkhead, as shown in Fig. 5, a cooler for the same water before it passes back to the pistons.

The exhaust pipes from the main engine are water-cooled up to and including the bend at the after end of the engine. On the centre of the engine-room bulkhead forward there are placed six air bottles, as shown in Fig. 8. The total capacity of these is about 86 cub. ft. These are charged by a Reavell auxiliary three-stage air compressor, having a capacity of about 230 cub. ft. per minute.

The arrangement of the shafting and bearings is well shown in the drawings on Plate XXXIV, and particularly in the cross-sections, Figs. 7 to 9. The line shafts are generally 9⅜ in. in diameter and 9½ in. at the bearings. The propeller shafts are 10½ in. in diameter, and are fitted with continuous gun-metal liners. The thrust shafts (Figs. 5 and 6) are provided with four collars, the thrust surface for ahead going being 532 sq. in. The thrust shoes are of cast-iron, lined with white metal. The propellers are of the solid cast-iron type.

The most interesting feature of the auxiliary machinery illustrated in Plate XXXIV is that it is steam-driven, as is the case with all the deck machinery, and to supply steam there are fitted, in a separate boiler room immediately abaft, but on a higher level than the main engine room, two boilers of the Cochrane type, each having 500 sq. ft. of heating surface and working at a pressure of 100 lb. per square inch, which is specially suitable for such auxiliary machinery. This boiler room is shown in Figs. 5 and 7, and also in plan in Fig. 10, Plate XXXIV, these views showing the oil-fuel arrangement. The oil-burning installation is in duplicate.

The oil fuel for working the boilers and also for the main engines is carried in the double bottom, which extends throughout the hold and machinery spaces, as shown in Fig. 6. The total capacity for oil fuel is 665 tons. On each side, on the upper deck level, there are placed two daily service fuel-oil tanks, each having a capacity of 15 tons, and placed abaft them, as shown in Figs. 5 and 7, is the Wallsend-Howden oil-burning installation.

Under the boilers and in the main engine room there is placed, as shown in Figs. 5 and 8, an auxiliary condenser, having 600 sq. ft. of cooling surface, to deal with the exhaust from the auxiliary machinery. It will be noted that the dynamo is run by a steam engine, this generator set being accommodated on a flat on the port side of the second deck, Fig. 7. The other steam auxiliaries include a duplex ballast pump, with a steam cylinder of 10 in. and a water cylinder of 10½ in. in diameter by 10-in. stroke, placed amidships at the after end of the engine room; a duplex general service pump, with cylinders 6 in. and 4 in. diameter and 6-in. stroke; a Weir simplex feed pump, with cylinders 5 in. and 7 in. by 12-in. stroke, and a 10-ton evaporator and distiller set.

The ship, which, as has already been stated, was constructed by Sir W. G. Armstrong, Whitworth and Co., Limited, at their Walker shipyard, is illustrated on this and the opposite page. The dimensions are:—

	ft.	in.
Length over all...	362	0
Length, between perpendiculars ...	350	0
Breadth extreme	47	3
Depth moulded to upper deck ...	27	0

As one of the pioneer vessels of the Flower Motor Ship Company, close consideration was given to the general arrangement of the ship, so as to take advantage, as far as possible, of the type of propelling power which had been adopted, and to apply this advantage to the cargo-carrying and working capabilities of the vessel. Reference to the views on the opposite page, Figs. 13 to 17, will show that the ship is divided into four clear holds, that the fuel is carried in the double bottom and peaks, with the exception of a small quantity, which is stowed in the poop to serve as emergency bunkers in case the temperature of the water in which the vessel is working is so low as to make it difficult to pump fuel from the main bunkers. The exigencies of the trade which the vessel was intended to carry out made 'tween decks necessary. Grain boards and feeder and trimming hatches are fitted.

After careful consideration it was decided that the propelling machinery constituted in itself a sufficiently large experiment, and that auxiliary deck machinery, consisting of a windlass, eight winches, steering gear, electric generating plant, &c., should, as we have stated above, be steam-driven, and follow exactly on the lines of similar plant usually fitted on cargo steamers. As we have already explained, steam for driving these auxiliaries is generated by the two Cochrane boilers, and the exhaust steam is led to a condenser in the engine room.

The total deadweight carrying capacity of the Abelia is 5,520 tons on a draught of 21 ft. Generally speaking, the scantlings conform to the usual cargo-vessel practice, and accord with Lloyd's requirements for their highest classification. The framing is on the "Isherwood" longitudinal principle. The ship and machinery have been built not only to the regulations and rules of Lloyd's Register, but to the Board of Trade requirements, and under the superintendence of Messrs. Flannery, Baggallay and Johnson, Limited, of Fenchurch street, London, E.C.

REFRACTORY MATERIALS.—The Faraday Society has arranged a general discussion on "Refractory Materials," on Wednesday, November 8, 1916, from 5.30 to 7 p.m. and from 8.30 to 10.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, London, W.C. (near Waterloo Bridge). Sir Robert Hadfield, F.R.S., president, will take the chair and will deliver an introductory address. The opening paper will be given by Dr. J. W. Mellor, and will deal principally with "The Texture of Refractories." Dr. H. G. Colman will speak on the work of The Joint Refractory Materials Committee of the Institution of Gas Engineers and the Society of British Gas Industries. Mr. Albert Cliff will speak on "The Manufacture and Prospects of Refractories." Mr. E. P. Page will speak on "The Classification of Refractory Materials and Some Notes on Method and Points for Investigation." Mr. J. Allen Howe will make a statement on "The Recent Work of the Geological Survey on Refractory Materials." Professor W. G. Fearnsides will read a paper on "The Application of Petrographic Methods to the Study of Refractory Materials." Mr. Cosmo Johns will read a paper on "Silica as a Refractory Material." Dr. P. G. H. Boswell will speak on "Refractory Sands." Mr. Ezer Griffiths, M.Sc., will read a paper on "The Transmission of Heat through Materials employed in Furnace Construction." Mr. F. W. Harbord, Professor J. W. Cobb, Dr. W. Rosenhain, F.R.S., and Mr. W. C. Hancock will also speak, and the subject will then be thrown open for general discussion

THE TWIN-SCREW MOTOR-SHIP "ABELIA," OF THE FLOWER MOTOR-SHIP COMPANY.

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, WALKER-ON-TYNE.

(*For Description, see opposite Page.*)

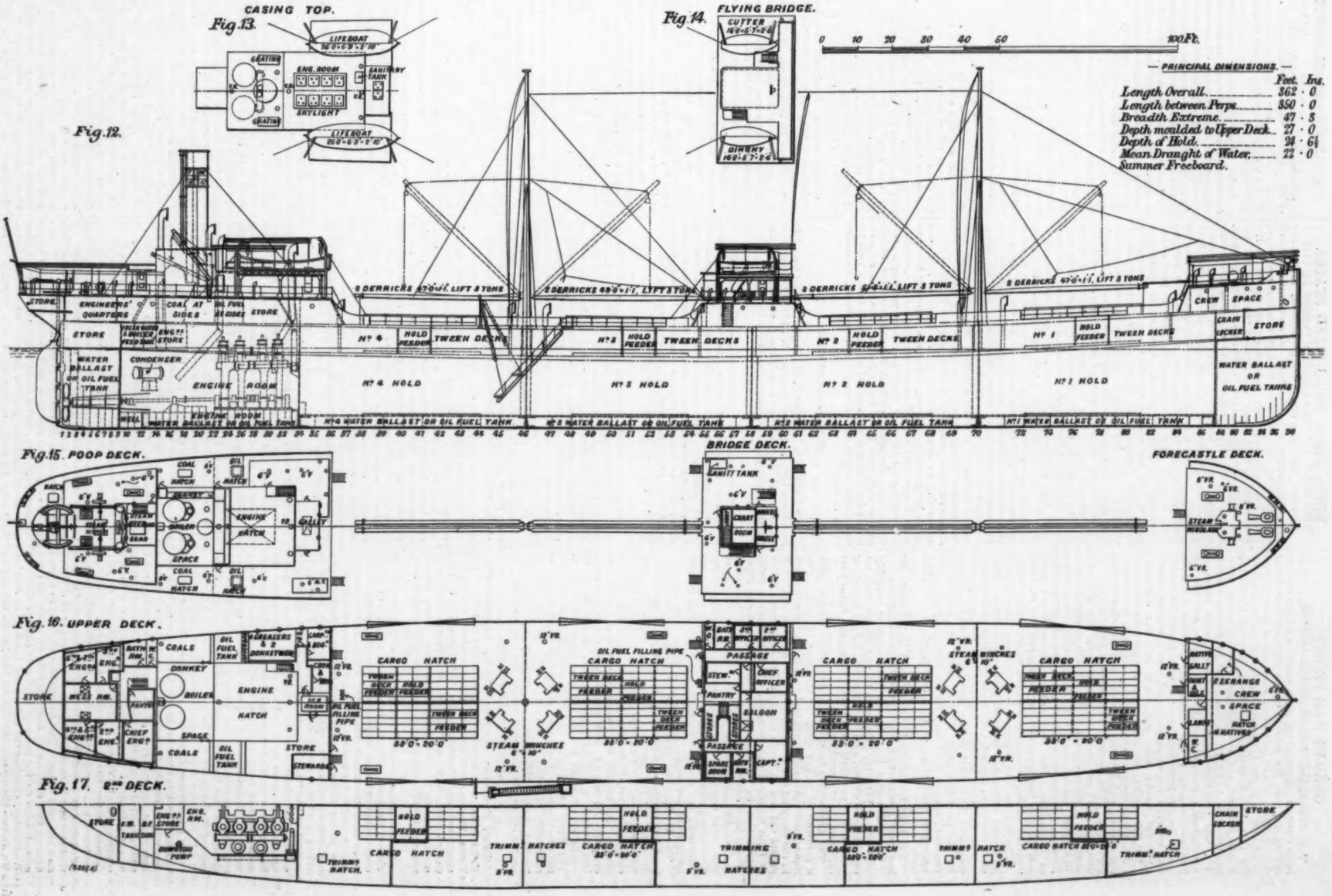


Fig.13. CASING TOP.
Fig.14. FLYING BRIDGE.
Fig.12.
0 10 20 30 40 50 100 Ft.
— PRINCIPAL DIMENSIONS. —
Feet. Ins.
Length Overall. 362 · 0
Length between Perps. 350 · 0
Breadth Extreme. 47 · 3
Depth moulded to Upper Deck. 27 · 0
Depth of Hold. 21 · 6½
Mean Draught of Water. 22 · 0
Summer Freeboard.
Fig.15. POOP DECK.
BRIDGE DECK.
FORECASTLE DECK.
Fig.16. UPPER DECK.
Fig.17. 2ND DECK.

GERMAN WAR PROFITS.

The Mannesmann Tube Works have, like many other large German industrial concerns, reaped a golden harvest during the war, the returns of the year 1915–16 being double those of the preceding year. The gross profits amounted to 31,184,176 marks, against 15,878,686 marks for 1914–15. Expenses, including those of the Grillo Funke concern and the Königin Elisabeth coal mine amounted to 4,791,610 marks. War profit tax reserve, &c., was provided for by 3,700,000 marks, ordinary writings-off amounted to 3,871,417 marks, &c., the net profits coming out at 16,987,224 marks, against 8,120,004 marks for the preceding year; a sum of 849,366 marks was reserved for employees' and men's welfare funds, 1,000,000 marks were put aside for war damages, 1,700,000 marks for restoration to peace production, 1,000,000 marks are to be applied to a special war welfare institution, and 500,000 marks to ordinary war welfare purposes. The board receives 416,342 marks. A dividend of 15 per cent. (10 per cent. for the previous year) on a share capital of 72,000,000 marks absorbs 10,800,000 marks, and 2,077,606 marks are carried forward. Prospects for the current year are pronounced as favourable. The Mannesmann Tube Works have just bought the majority, or, rather, 800 out of 1,000 "parts," of the Wilhelmine Iron Ore concern, Siegerland.

The Menden und Schwerte Iron Company has doubled its profits during last financial year and pays a dividend of 10 per cent., against 4 per cent. for the preceding year.

The Harpener Mining Company had last year gross profits of 35,105,641 marks, against 25,889,157 marks for the preceding year. The dividend was fixed at 12 per cent., against 6 per cent. for the previous year. The aggregate production of coal amounted to 7,302,353 tons.

The Pöge Electricity Company paid 15 per cent. for last year, against 7½ per cent. for the preceding year.

The Geisweider Iron Works have done exceedingly well during 1915–16, being able to pay 20 per cent. on the preferred shares, against 6 per cent. for the preceding year, and 18 per cent. on the ordinary shares, against no dividend for the previous year.

The Lindenberg Steel Works, Remscheid-Hasten, paid a dividend of 25 per cent. for the year 1915–16. The report states that the works had principally been devoted to the carrying out of military orders, and the handsome profits did not so much emanate from increased prices as from technical achievement, which had given great satisfaction to all concerned. The Lindenberg Steel Works have entered into close relations with the Felten and Guillaume concern, Mülheim, and the director of this latter company has been elected a member of the Lindenberg company's board, another instance of that combining and amalgamating process which is at present going on in Germany.

The Westphalian Iron and Wire Company, at Werne, paid a dividend of 6 per cent. for last year, against no dividend for the previous year. The works are very fully employed for a number of months to come, but the embargo on many products is an unfavourable circumstance. As regards the rumoured combine in the wire industry 106 firms in this branch had, the report says, just formed a "loose" convention; some 50 to 60 works have not yet joined, but were expected to do so. The object was principally to tide over the time between the commencement of peace negotiations and the actual conclusion of peace, a period which was expected to present some difficulties. A regular syndicate was looked for as the final outcome of the negotiations.

Town Planning.—Professor S. D. Adshead, M.A., F.R.I.B.A., will deliver six public lectures on "The Town Planning of Greater London after the War," illustrated with lantern slides, at University College, Gower-street, W.C., on Tuesdays, at 5.30 p.m., beginning on November 7, 1916. Admission free. Seats will be reserved for ticket-holders on application to the secretary.

Smoke from Steam Wagons and Tractors.—In view of the great difficulty in securing supplies of steam coal for use in steam wagons and tractors, owing to the great demand for such coal by the Navy, the Commercial Motor Users' Association addressed a communication to the Home Office, urging that, having regard to the national importance of road transport, action should be taken to allow a very considerable degree of latitude in respect of the "temporary and accidental" emission of smoke from these vehicles before any action is taken against any owner or driver for an offence against the Locomotives on Highways Act, 1896. A reply has now been received from the Home Office in the following terms:—"I am directed by the Secretary of State to say that his attention has already been drawn to the question, and he has communicated his views in the matter to the police."

An Important Decision affecting Heavy Motor Cars.—The Commercial Motor Users' Association has just won an important appeal case on behalf of users of heavy motor cars. One of its members was summoned and convicted at the Birkenhead Police Court for causing a 4-ton Sentinel steam wagon to stand on a bridge contrary to by-laws made by the Chester County Council under the Locomotives Act, 1898. Although evidence was produced to show that the vehicle was registered as a heavy motor car, the magistrates held that it was a locomotive within the meaning of the Act, and imposed a fine. The Association decided to appeal against this decision in the interests of users, and the appeal came on for hearing in the Divisional Court on Wednesday, October 25, before the Lord Chief Justice, Mr. Justice Ridley and Mr. Justice Low, when the appeal was allowed with costs.

NOTES FROM THE UNITED STATES.

Philadelphia, October 18, 1916.

Demand for steel continues to expand, and many large consumers are uncertain of securing sufficient supplies next year to cover work now being contracted for. Railroads are once more a strong factor in the steel market, 25,000 cars having been placed in the last five weeks, and inquiries for 10,000 cars are now pending, all calling for about 400,000 tons of steel. Railroads are also buying heavily of structural steel and have already contracted for 100,000 tons of rails for 1918 delivery, at 33 dols. per ton. The thought of waiting for lower prices has been dissipated, and the only thought now is to be sure of material for over a year ahead regardless of present prices. Agricultural implement makers and automobile interests are now contracting for distant deliveries at prices which they refused to consider a few months ago; just to what extent prices may advance is a matter of pure conjecture. The uplift of prices and the long-oversold conditions account for the present rush. The estimated output of tin-plate for next year is put at 60,000,000 boxes. The pig-iron situation presents a curious situation affecting basic and Bessemer. Nearly all large steel-makers are in the market for large quantities. European inquiries are again combing the market for best possible deliveries. Only two furnaces out of the 59 furnaces of the Steel Corporation are idle; there are only two idle furnaces in Alabama. Great exports of pig are being arranged for next year. Competition for steel plate has driven prices to 4 cents a pound in many cases, and foreign interests are largely responsible for this activity. Japan has now contracts in this country for steel plate amounting to almost 60,000 tons. Much of this steel is for next year's delivery. The rail capacity for next year is now sold up. Russian negotiations for supplies move along very slowly; there have been pending a good while, and are still pending, negotiations for 38,000 freight cars and 1,000 locomotives. The rail requirements for Russia are estimated at 250,000 tons a year for five years, which this country will probably be called upon to supply.

The Late Mr. Robert C. McKinney.—We regret to announce the death, on October 3, at Greenwich, Connecticut, of Mr. Robert C. McKinney, chairman of the Niles-Bement-Pond Company, aged 65.

Locomotives in Argentina.—The number of passenger locomotives upon the Central Argentine Railway at the close of June was 348. The number of mixed passenger and goods tender engines was 70. The number of goods engines upon the system was 174 and the number of shunting engines was 100. The aggregate number of engines owned by the company at the close of June this year was, accordingly, 695.

Bristol Sandwich Scheme of Engineering Training.—In addition to the numerous firms who have offered facilities in connection with this scheme, Messrs. Wolseley Motors, Limited, Birmingham, have also offered two Wolseley scholarships to be granted on the results of the intermediate examination for the B.Sc. Degree in Engineering of the University of Bristol; this will excuse the winners from payment of the usual works premium (at the rate of 100*l.* a year) and will entitle them to remuneration at the rate of 10*s.* a week for the first two periods of 14 and 2 months respectively while in the works, and 1*l.* a week for the last period of 14 months.

Siberian Metallurgy.—New iron and steel plant is in contemplation in Siberia. A meeting was recently held between representatives of the Russian Government and the Russian iron trade, and it was decided to raise a capital of 20,000,000 roubles, the interest to be guaranteed. The Government is to lease to the company for a term of 60 years the district of Kusnezk, where the proposed works will be situated, and the company is to supply a fixed tonnage of rails and other railway *matériel* annually. The district has coal and iron deposits estimated at a total of 1,594,000,000 poods (a pood is 36 lb. English), and the ore yields from 58 to 65 per cent. of iron.

Diesel Engine Users' Association.—The first of the autumn meetings of the Diesel Engine Users' Association after the summer recess was held on October 20. After the election as members of the association of several engineers having the control of Diesel engine plant, certain resolutions were passed providing for alterations and additions to the rules. From the end of the current year an entrance fee of one guinea is to be charged to all new members elected. To meet the demand which has arisen in many quarters for copies of the reports of proceedings and of the general information and data circulated by the association, provision has been made for a class of "subscribers." Such "subscribers," who must be duly accepted by the committee, would consist of individuals or firms who are not qualified for full membership, and who would be entitled to receive the particulars circulated on payment of a sum of one guinea per annum. They would not be entitled to attend the meetings of the association (except by special invitation of the committee), neither would they have any voice in the control of the association. "Subscribers" may at any time send communications to the honorary secretary, and if in the opinion of the committee they are of sufficient general interest, such communications may be read and discussed at a meeting of the association.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—The featureless condition of the pig-iron warrant market still continues, no effort being made in the meantime to revive its activities. In the public stores the stocks of pig-iron are gradually growing less.

Scotch Steel Trade.—In the local steel trade the excessive demand for all classes of finished material required for the purposes of the war remains the outstanding feature. Wherever possible efforts are being made to increase the output, every available mill being, in the meantime, constantly employed rolling material for Government contracts. Steel for shell bars is still in great request. Inquiries for steel for export are coming well to hand, but the licensing question prevents anything much in the way of business being put through. A slight advance in price has taken place, and while angles are still quoted at 14*l.* 7*s.* 6*d.* per ton, ship plates are now 14*l.* 5*s.* and boiler plates 15*l.* 10*s.*

Malleable-Iron Trade.—Excellent business continues to be done by the malleable iron makers, the phenomenal demand constituting a heavy pressure on their resources, both in the steel and iron departments, most of which, of course, is required either directly or indirectly on Government account. For ordinary "Crown" bars the price quoted is still about 14*l.* 12*s.* 6*d.* per ton, special qualities realising a few shillings extra.

Scotch Pig-Iron Trade.—Still there is little change to be noted in connection with the pig-iron trade, for while the demand continues on a large scale and under maximum prices and control, so much is being required for Government purposes that no export is permitted, either of hematite or foundry sorts, except for the use of the Allies. This has been rendered necessary by the fact that even the abnormal output is quickly absorbed by the local steel works engaged on war contracts. Movements, consequently, are infinitesimal other than under Government control. Without doubt this state of affairs is reacting adversely on ordinary mercantile business. Firm rates continue to be well maintained.

Glasgow's New Electricity Works.—The scheme for augmenting the supply of electricity, to keep pace with the ever-increasing demands, has at length taken concrete form. In November, 1911, a site for the erection of a new generating station was purchased, and when this eventually came into the actual possession of the Corporation, offers for the clearing of the ground and the laying of the foundations were accepted, but on the outbreak of war in August, 1914, the matter of the erection of the new works was temporarily set aside, the Corporation deciding that, beyond the necessary work which had already been arranged for, nothing further should be done. Now, however, the time has come for definite action, Mr. W. W. Lackie, electrical engineer to the Corporation, having intimated that it was no longer possible for him either to connect new consumers or supply them with electricity. The erection of a portion of the new generating station at Dalmarnock Bridge will now be proceeded with, Mr. Lackie having been empowered to obtain estimates for the necessary work, these to be submitted to the Electricity Committee at the earliest possible opportunity.

Associated Ironmoulders' Accounts.—It is interesting to note that, despite the constant demands of the Army and Navy, and the consequent depletion of the ranks of the workers engaged in civil occupations, the income of the Associated Ironmoulders of Scotland shows, during the past four weeks, an increase of 304*l.* over the income of the previous four weeks. Mr. John Brown, the general secretary, has just intimated this highly satisfactory statement in the current monthly report, adding also that at the moment the funds at the credit of the association amount to 57,559*l.*

More Chinese Railways.—The Chinese Government has placed contracts with the Siems Carey Company, of St. Paul, Minnesota, for the construction of more than 2,000 miles of railways in China. The Siems Carey Company is financed by the American International Corporation, of New York.

The Institution of Automobile Engineers.—The first general meeting of the session of the London graduates of the Institution of Automobile Engineers was held on Thursday, October 26, 1916, when Mr. T. D. Carpenter read a paper on "Factory Organisation," Mr. L. H. Pomeroy (vice-president of the Institution) being in the chair. In the course of his paper the author dealt with the functions of the various departments of the factory and their method of producing results. He pointed out that the works manager should be the driving force of the works staff and should attend not only to matters of importance but also to details. The designs and drawing office should be responsible for producing a practical design with working drawing, correct in all details before the actual production is commenced. Operations should be arranged in proper sequence, time-saving tools designed, the minimum times of operations deduced and waste movements eliminated. The author then went on to outline the functions and duties of the ordering department, the stores, the costing department, and the experimental department. He also recommended the adoption of the premium bonus system as the only method of obtaining output at a minimum cost, the advantage being that both the worker and the employer benefit from it. An interesting discussion followed the paper, and some extremely valuable hints in regard to organisation were given by the chairman. A vote of thanks to the author concluded a very interesting and successful meeting.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The most pressing demand is for gas-making fuel. Both inland works and overseas consumers are asking for exceedingly heavy deliveries, and house-coal pits are kept at the full stretch to cope with the requirements. Fortunately the orders from householders themselves show a slight falling-off, and the position is thus somewhat equalised. Steam hards are likewise a brisk trade, and the daily output is automatically absorbed by contracts, with the result that little or nothing finds its way on to the open market. Some improvement is reported of the shipments of South Yorkshire hard *via* Hull, but this chiefly concerns allied Powers, for the home demands are so great that little can be spared for neutrals, even though the latter offer higher prices. Cobbles, nuts and slacks are all in a firm position. Cokes are none too easy to obtain, supplies having fallen off somewhat from various causes. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at pit.

Iron and Steel.—The position is becoming increasingly difficult in all branches of the Sheffield industries. There are three obligations to fulfil, each of enormous importance. War material output has to be accelerated as much as possible, the export trade has to be maintained, and men have to be released for the Army. The problem does not lend itself to a ready solution, and it is exercising the minds of the different Government departments concerned. The outcome of the deliberations is awaited with interest in Sheffield. All sections of the trade are working at the maximum pressure. The steel trade is particularly busy, with consequent increasing calls on the material market. The wholesale sinking of the Norwegian shipping is reflected in the deliveries of Swedish iron and steel, but fortunately fairly heavy stocks are held by the larger firms. Amongst the latest quotations are the following:—Bessemer acid billets, 14*l.*; Siemens acid, 15*l.*; hard basic and soft basic, 12*l.* 10*s.* There is not much buying of American steel billets, for they are disappointing in quality and quantity. Silica bricks for the lining of furnaces are now more easily obtained. Files have also been in great demand, not only for Russia and the home trade, but for such places as Buenos Ayres, Calcutta, Barbados, Montreal and the Philippines. The cutlery manufacturers are having to neglect the home market in carrying out the Government's instructions to fulfil Army and Navy requirements, and look after the export trade. Orders for tools, saws, steel, sheep shears, plane irons, electro-plate and cutlery continue to arrive from overseas.

Sheffield Trade Matters.—The Wolf Safety Lamp Company, which has an extensive business connection, has been acquired by a Sheffield gentleman. Prior to the war the principal financial interests were in the hands of a Bremen financier. Following the recent compulsory winding-up, however, it has been acquired by Mr. W. Maurice, who was for some time manager of the Sheffield works. The business has now assumed large proportions and it may soon become necessary to extend the accommodation.

EXPORT OF SWISS ELECTRIC ENERGY.—According to recent statistics, the Swiss Diet has, during 1914 and 1915, granted five concessions for the export of electricity, of which three refer to Germany, with an aggregate of 15,015 kw.; one refers to France, with an aggregate of 10,000 kw.; and one refers to Liechtenstein, with an aggregate of 200 kw. The latter was for a period of three years. Of the others, one was for 15 years and the other for 20 years.

METALLIC PERMANENT WAY.—There has been a great falling-off this year in the foreign and Colonial demand for metallic permanent way material. The exports for September were only 539 tons, as compared with 5,186 tons in September, 1915, and 706 tons in September, 1914. This was due to the fact that deliveries to British India for the month declined to 122 tons, as compared with 5,070 tons and 705 tons. In the nine months ended September 30 this year we exported permanent way material—that is, metallic chairs and sleepers—to the aggregate extent of 9,770 tons, as compared with 50,469 tons in the first nine months of 1915, and 61,945 tons in the first nine months of 1914. India figured in this year's shipments for 4,530 tons, as compared with 36,059 tons and 52,497 tons. The value of the exports to September 30 this year was 89,744*l.*, as compared with 376,558*l.* and 377,031*l.*

THE BRIQUETTE INDUSTRY IN GERMANY.—The Rhenish Briquette Sales Union comprises works with an aggregate annual allotment of 8,010,000 tons. During the last financial year the aggregate deliveries, including those of a concern not officially belonging to the Sales Union, amounted to 5,587,686 tons, or 69.76 per cent of the allotment for the year. The sales of the syndicate amounted to 5,680,542 tons, thus slightly exceeding the production. Of this total 3,552,699 tons, or 62.54 per cent., were household briquettes, and 2,127,843 tons, or 37.46 per cent., industrial briquettes. The Union Company of Rhenish Lignite Mines, into which the Rhenish Briquette Sales Union has evolved, has increased its capital by 6,000,000 marks. The rise in the price of briquettes effected during the year has not made up for the increase in cost of production; for the current year no rise in the quotations is contemplated.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Firmness continues to characterise the market, and a fair amount of business in Cleveland pig is being put through. Pressure on the output is heavy and is by no means easily met. Considerable bookings to the end of the year for English foundries are reported, and demand for November delivery to customers north of the Tweed continues insistent. Consumers are anxious to cover requirements over the first quarter of next year, and some purchasing for the early months of 1917 has been made. Makers generally, however, are not disposed to enter into contracts for supply beyond the end of the year. Forge iron is fairly plentiful, and is now being taken up to some extent in place of superior qualities. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge, all stand at 87*s.* 6*d.*, and No. 1 is put at 91*s.* 6*d.* For exports offers to pay 101*s.* for prompt shipment of warrant iron fail to tempt holders to sell what little they possess. Makers No. 3 is 97*s.* 6*d.* and upward for export; No. 4 foundry is 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*

Stock of Cleveland Pig-Iron.—During the month of October the stock of Cleveland pig-iron in the public warrant stores here was reduced by the withdrawal of 8,156 tons of No. 3, and the quantity held now stands at 4,434 tons, composed of 4,398 tons of No. 3 quality, and 36 tons of other kinds of iron deliverable as standard. There are warrants in circulation for 2,500 tons, all of which is No. 3 quality.

Hematite Iron.—Conditions continue unfavourable to the transaction of new business, but sales are recorded from time to time. Makers generally have sold their output as far ahead as they care to commit themselves, and merchants have command of little iron for disposal. Nos. 1, 2 and 3 remain at 122*s.* 6*d.* for home consumption; whilst the price for shipment to France is 137*s.* 6*d.*, and for export to Italy 142*s.* 6*d.*

Foreign Ore.—Large orders for foreign ore are understood to have been placed. Lack of tonnage is interfering somewhat with deliveries, but imports are still on such a scale as to enable consumers to continue to add considerably to their already very heavy stocks. Unloadings at Middlesbrough during October reached 152,770 tons.

Coke.—There is continued good demand for coke for local consumption, and prices are upheld notwithstanding the plentiful supply. Medium blast-furnace kinds are still realising 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens continues to be asked for qualities low in phosphorus.

Manufactured Iron and Steel.—Producers of finished iron and steel continue very fully employed. Government needs absorb most of the output, but a considerable quantity of material for mercantile shipbuilding is now being turned out. Quotations all round are very strong. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.* according to diameter; packing iron and steel (parallel), 11*l.*; packing iron and steel (tapered), 13*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strips, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during October amounted to 92,018 tons, 53,610 tons being pig-iron, 4,522 tons manufactured iron, and 33,886 tons steel. Of the pig-iron despatched 53,291 tons went to foreign ports and 319 tons to coastwise customers. As has been the case for some time past, France was by far the heaviest customer, receiving 40,930 tons, Italy being second, with an import of 6,421 tons; whilst Spain took 3,000 tons and the United States of America 2,000 tons. Of the manufactured iron cleared, 1,739 tons went abroad and 2,783 tons coastwise, India and Japan being the largest importers, the former receiving 651 tons and the latter 409 tons. Of the steel shipped, 33,561 tons went foreign and 325 tons coastwise. Once more France was the largest buyer, taking 27,415 tons, and the other principal purchasers of steel were: India, 2,521 tons, and Italy 2,017 tons.

CENTRAL ARGENTINE RAILWAY.—The gross receipts of the Central Argentine Railway in 1915–16 were 5,737,093*l.*, while the working expenses of the year were 3,702,099*l.*, leaving the net receipts at 2,034,994*l.* In 1914–15 the gross receipts were 5,755,254*l.*, while the working expenses were 3,363,055*l.*, leaving the net income at 2,392,199*l.* It will be seen that the gross receipts were nearly maintained last year, but that the working expenses were larger by 339,044*l.* The falling-off observable in the receipts has continued this year. This is due to the abnormal state of Argentine affairs resulting from the war in Europe. The company's new electrified line between Buenos Ayres and Tigre, via Victoria, has been opened for traffic; progress has also been made with workshops at Perez and with station works at Cordoba. These are the only works of importance at present in hand on capital account; they had been commenced before the outbreak of the war. The ratio of the working expenses to the traffic receipts stood last year at 64.53 per cent., as compared with 58.43 per cent. in 1914-15. The higher cost of fuel alone adversely affected working expenses by 178,725*l.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—A heavy gale, by delaying the arrival of expected steamers, made the disorganisation of loading arrangements more complete; and with excessive stocks of coal standing, many colliery owners found it difficult to clear trucks quickly enough to avoid pit stoppages. Under these circumstances, buyers for immediate delivery secured substantial reductions from recently quoted prices. Occasional sales at prices equivalent to the maximum limitation terms for France and Italy were made for other directions; scarcity of steamers, however, prevented any important amount of prompt business being transacted. House coal has shown no change, and a similar report may be made as regards patent fuel and coke. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 34*s.* to 35*s.*; Monmouthshire Black Veins, 34*s.* 6*d.* to 35*s.* 6*d.*; ordinary Western Valleys, 34*s.* to 34*s.* 6*d.*; Eastern Valleys, 32*s.* to 33*s.*; best bunker smalls, 24*s.* to 25*s.*; and cargo smalls, 19*s.* to 21*s.* per ton. In bituminous coal, best households have brought 25*s.* to 25*s.* 6*d.*; No. 3 Rhondda large, 35*s.* to 36*s.*; smalls, 28*s.* to 30*s.*; No. 2 Rhondda large, 30*s.* to 32*s.*; and No. 2 smalls, 20*s.* to 21*s.* per ton. The latest quotation for patent fuel has been 40*s.* to 42*s.* 6*d.* per ton. Special foundry coke for export has realised 62*s.* 6*d.* to 65*s.*; good foundry coke, 57*s.* 6*d.* to 60*s.*; and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.* per ton.

Western Trade Matters.—The Nantyglo and Blaina Ironworks Company, Limited, has declared a dividend of 4*l.* per share on account of arrears on the 8 per cent. preference shares. This makes a distribution of 7*l.* per share for 1915–16. The amounts paid upon the shares for the five years ending with 1916 inclusive have been as follow:—1912, 5*l.* per share; 1913, 4*l.* 10*s.* 6*d.* per share; 1914, 6*l.* per share; 1915, 6*l.* per share; and 1916, 7*l.* per share. At the close of September, 1916, the arrears of preference dividends outstanding amounted to 523,958*l.*—In connection with a scheme to reduce absenteeism on the part of workers underground in coal mines which came into force towards the end of June, the Monmouthshire and South Wales Coalowners' Association has issued completed returns for three months ended September, 16. The total number of coal mines included in the returns is 275, but miners have not given effect to the scheme at all the pits, and the number of collieries at which returns were jointly signed has only averaged 39 during the quarter. The returns, which apply to underground men only, give an average avoidable absenteeism over the whole period of 8¼ per cent., and an average absenteeism from causes beyond the control of the workmen and through failure of workmen to attend, although able to do so, of 11¼ per cent. The maximum possible number of shifts which could have been worked during the quarter was 10,414,387; of this number 911,257 were lost through avoidable absenteeism and 307,225 through causes over which workmen had no control, making an aggregate of 1,218,482. Taking the whole country, avoidable cases of absenteeism are estimated at 4¼ per cent.—The directors of the Main Colliery Company, Limited, propose to divide each of the existing 10*l.* shares in the company into 10 fully-paid shares of 1*l.* each, the minimum share application to be 50 of the new 1*l.* shares.—The profits of the Weatherall Steamship Company for the past financial year were 23,365*l.* and 468*l.* was brought forward; the dividend for the 12 months has been fixed at 25 per cent. per annum, 6,000*l.* being at the same time written off the book value of the company's steamers and 3,083*l.* being also transferred to the reserve fund.—The iron steamer Ivor Aaser, built at Newcastle in 1867, 225 tons deadweight, has been sold for 6,700*l.*; she was sold in March, 1915, for 2,300*l.*—The steel steamer Grelford, built at Sunderland in 1898, 4,850 tons deadweight and owned by the Haenton Steam Shipping Company, has been sold to Messrs. Watkin, Williams and Co., Cardiff, for 75,000*l.*; in November, 1915, when she was previously sold, she realised 43,000*l.*—Lord Rhondda, Mr. A. Michelson and Mr. H. Seymour Berry have acquired the control of the International Coal Company, Limited, which owns collieries at Blaengarw, producing about 200,000 tons of house coal annually. It is understood that the purchase price is 9*l.* per 5*l.* share; this is offered to shareholders who have not already agreed to sell, subject to acceptance within 14 days. Lord Rhondda has been elected to the board of directors, and will become the chairman of the company. The share capital of the International Company is 85,000*l.*, all in ordinary shares of 5*l.* each. The profits for 1915-16 were 17,256*l.*, and a dividend of 15 per cent. was paid for the year.—Lord Rhondda acknowledged the toast of "Cardiff's youngest freeman" at a luncheon given by the Lord Mayor of that city on Friday, and observed that he did not think that Cardiff had yet reached the zenith of its fame in the coal trade. With regard to the relations of capital and labour he was hopeful that, after the war, employers would be able to meet their labour friends in a better spirit; their interests were, after all, identical. Cardiff must look out and see that it got the benefits which resulted from the carbonising of highly volatile coal at a low temperature. When peace came, we should be able, he believed, to meet the Germans in every way, for we had just as much brains, initiative and courage.—The Bristol Waterworks Company is promoting a 300,000*l.* scheme for obtaining a larger supply of water from Cheddar. It is proposed to allow Cheddar Pond and the Cliff-House waterfall to remain as at present, and to take surplus water from a point in the garden of the Cliff Hotel near the bridge; this water would be carried through pipes to a place near the railway station; here a pumping station would be erected, and water would be pumped into Blagdon reservoir—a distance of 10 miles.

THE ACCIDENT TO THE QUEBEC BRIDGE.

(*For Description, see Page* 441.)

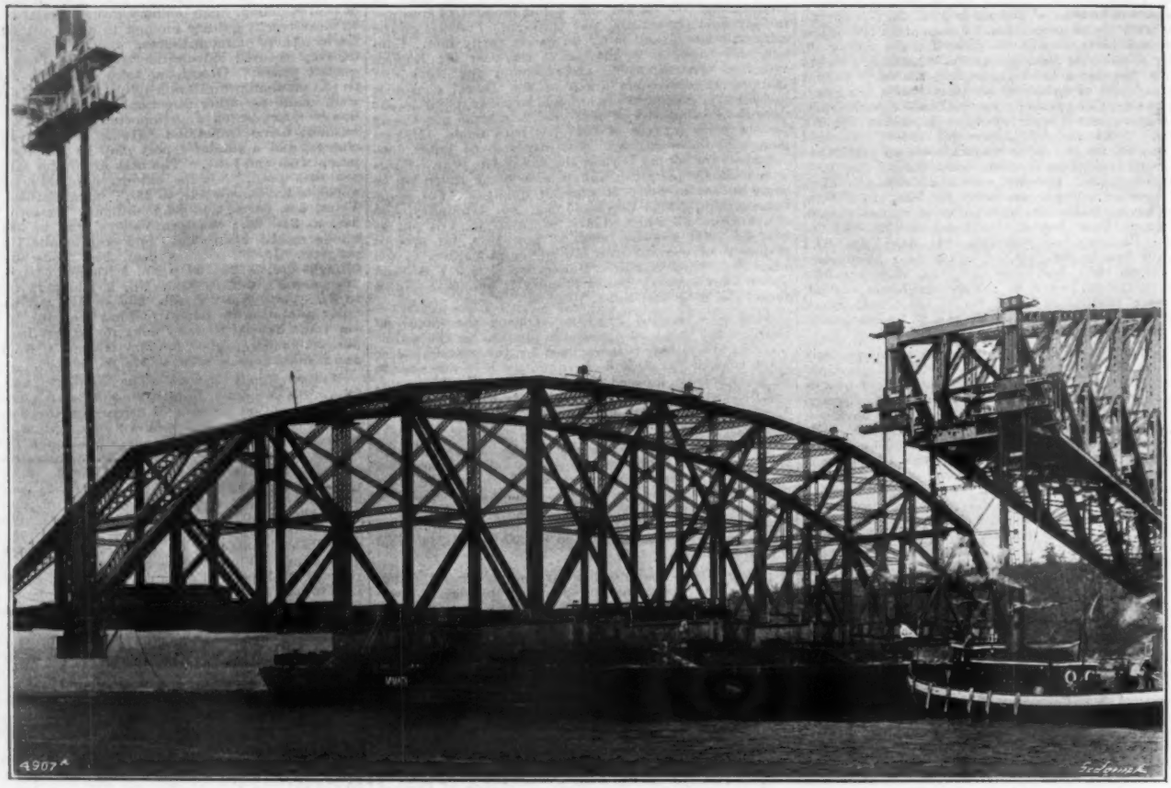


FIG. 1. THE SUSPENDED SPAN IN POSITION FOR LIFTING.

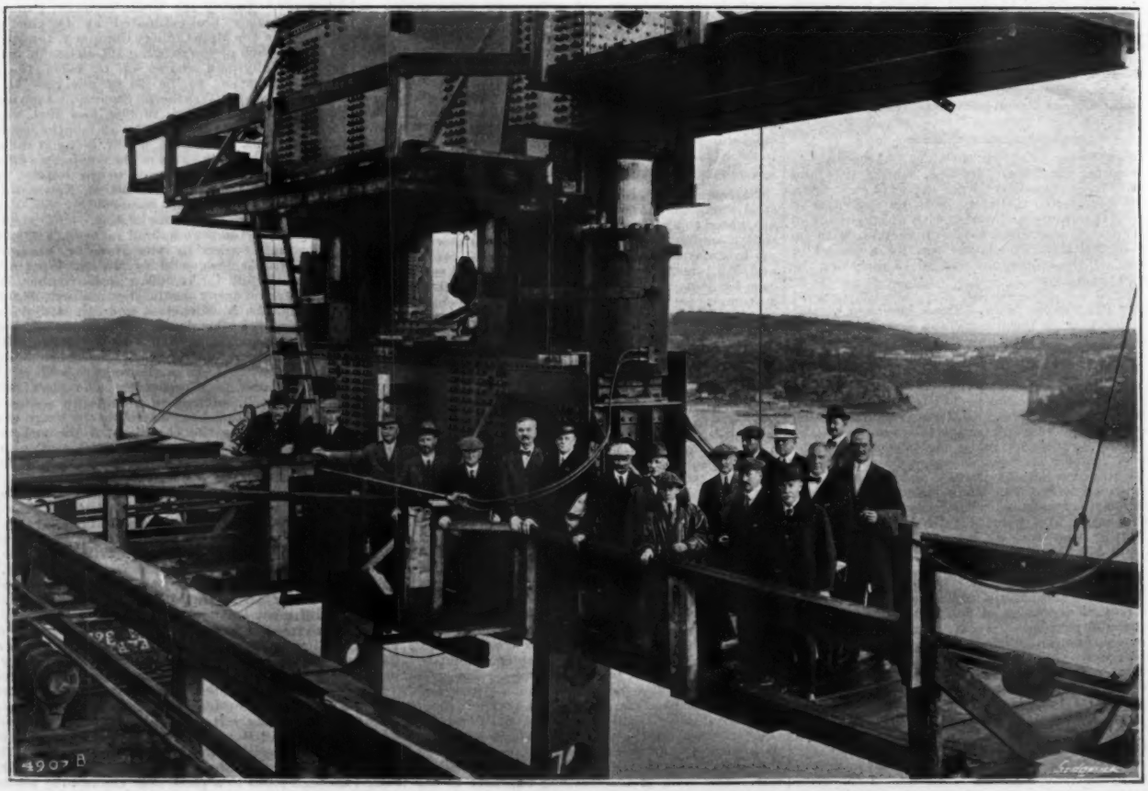


FIG. 2. ARRANGEMENT OF HYDRAULIC JACKS AND PUMPS ON THE CANTILEVER ARM.

GENERAL ARRANGEMENT OF MACHINERY IN

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINE

(For Description, see P

Fig. 5.

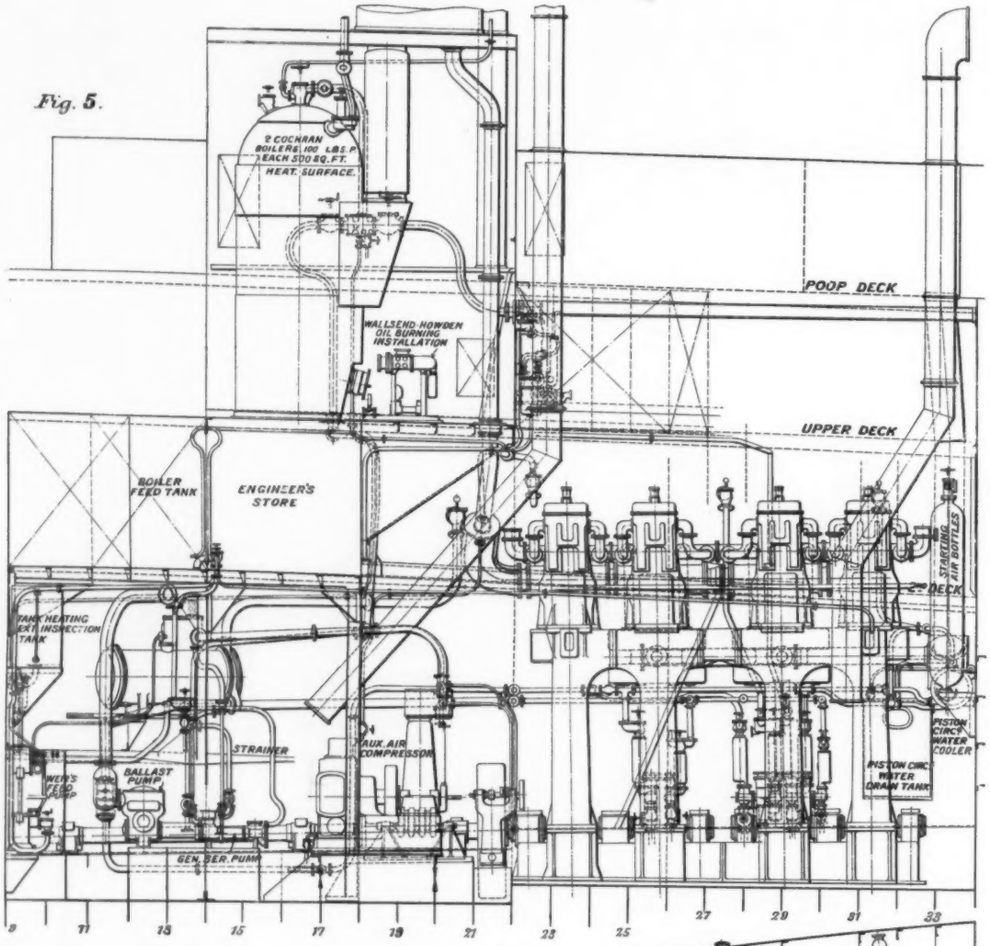


Fig. 6.

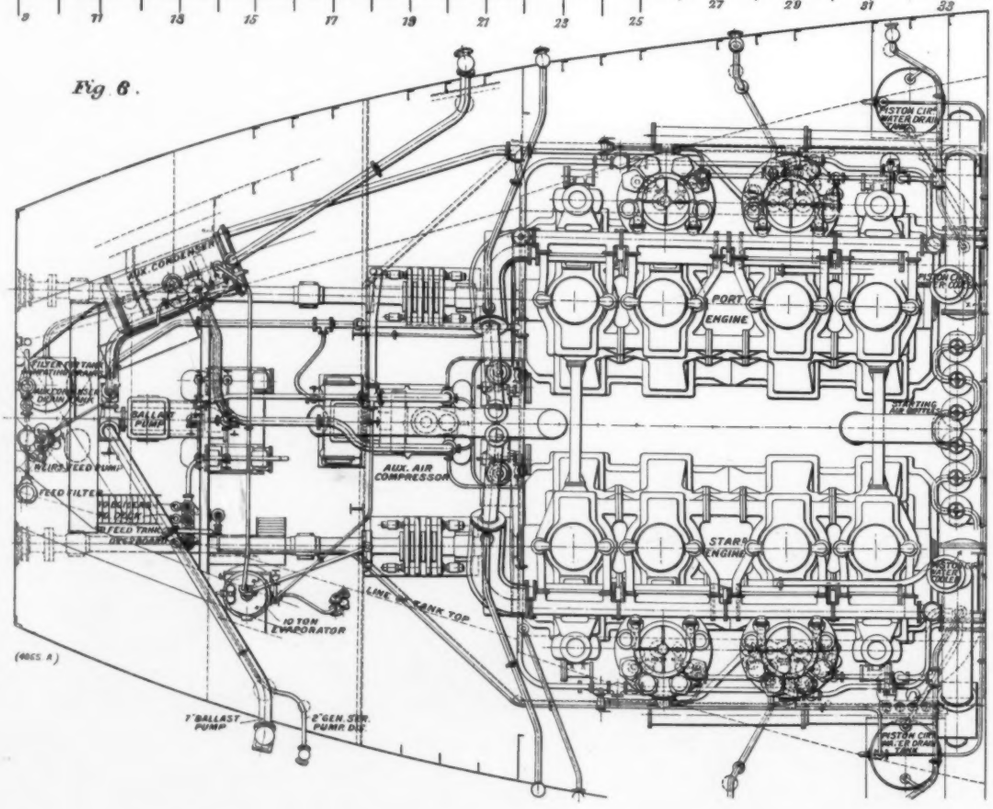


Fig. 7.
SECTION AT FRAME Nº22 LOOKING AFT

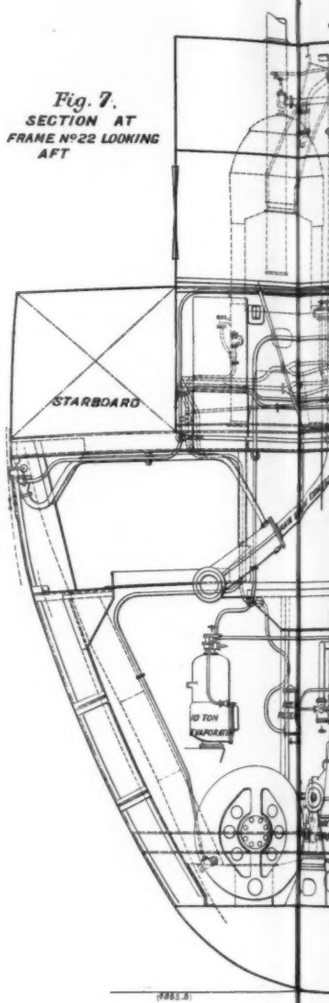
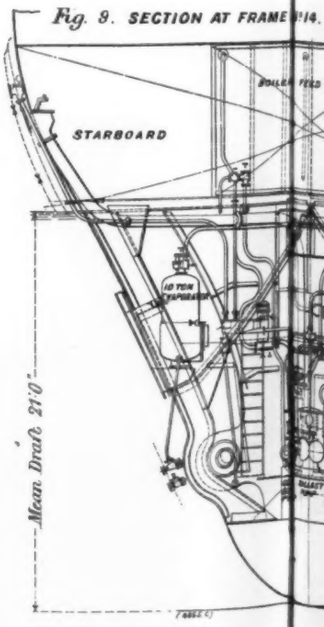


Fig. 9. SECTION AT FRAME Nº14.



RY IN THE TWIN-SCREW MOTOR-SHIP "ABELIA."

AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

escription, see Page 434.)

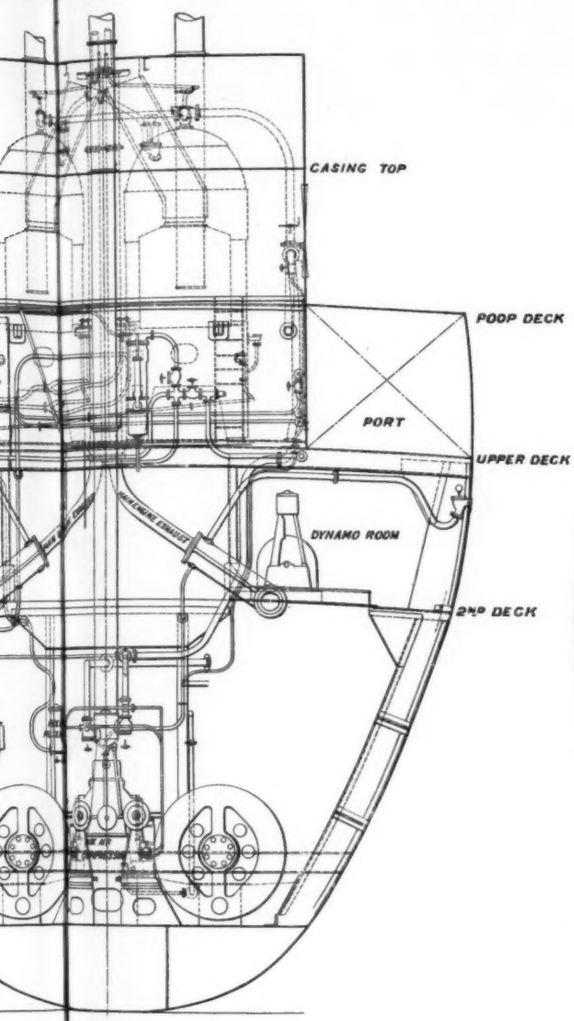
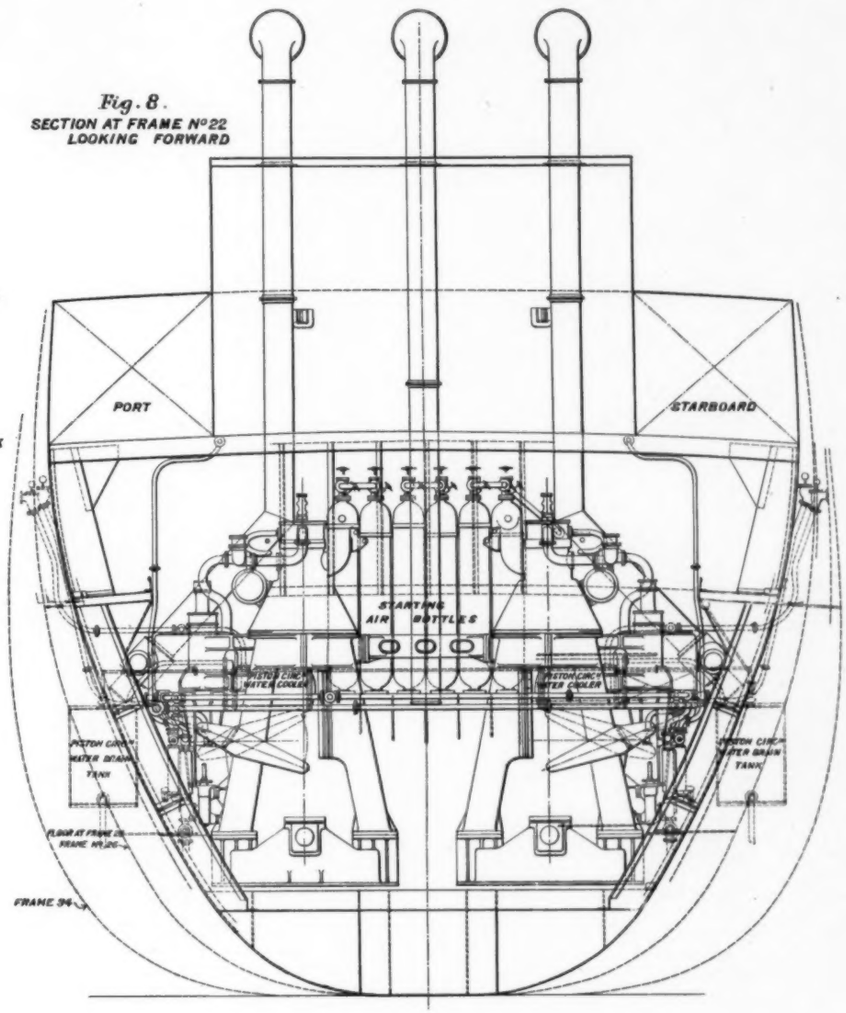


Fig. 8.
SECTION AT FRAME Nº22
LOOKING FORWARD



T FRAME Nº14. LOOKING AFT.

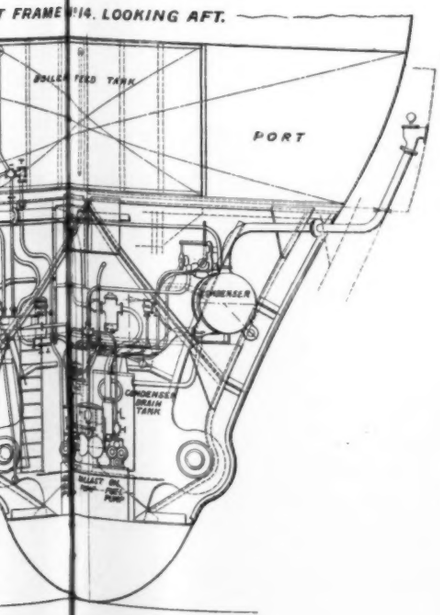
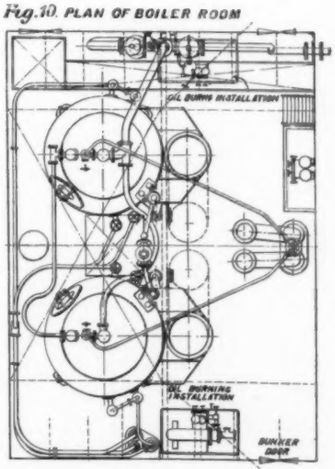


Fig. 10. PLAN OF BOILER ROOM



PARTICULARS OF MACHINERY.

MAIN PROPELLING ENGINES (DIESEL TYPE):—

Diameter of Cylinders	17¼ In.
Stroke...	33 In.
Revolutions per Min.	120
Collective B.H.P.	1200
Capacity of Compressors per Min. ...	230 Cub. Ft.
Capacity of Fuel Tanks	665 Tons.
Capacity of Air Bottles	87 Cub. Ft.

STEAM BOILERS FOR AUXILIARIES:—

Heating Surface	500 Sq. Ft.
Steam Pressure (per Sq. In.)	100 Lb.

STEAM AUXILIARIES:—

Duplex Ballast Pump	...10 In. and 10½ In. by 10 In.
Duplex General Service Pump ...	... 6 In. and 4 In. by 6 In.
Oil Tank Pump	... 6 In. and 4 In. by 6 In.
Weir Simplex Feed Pump... ...	... 5 In. and 7 In. by 12 In.
Evaporator and Distiller	10 Tons.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson & Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaugnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie B. Tignol, 55bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-958, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom £1 15 6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—

Thin paper copies £1 11 6 (£7.65)
Thick " £1 16 6 (£8.75)

For all other places abroad—

Thin paper copies £1 16 0
Thick " £2 0 6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8508 GERRARD.

CONTENTS.

	PAGE		PAGE
Spark Ignition	427	Nitrogen Oxides from Ammonia for the Lead-Chamber Process	440
The Arrangement of Machine Shops.—No. VI (*Illus.*)	429	The Accident to the Quebec Bridge (*Illus.*)	441
Water Powers of Canada	431	Notes	444
Industrial Notes	432	Diagrams of Three Months' Fluctuations in the Prices of Metals	445
Starting Diesel Engines with Low Compression	433	Literature	446
The Twin-Screw Motor-Ship "Abelia" (*Illus.*)	434	The late Dr. Charles A. Harrison (*with portrait*)	446
German War Profits	436	The Development of Appliances for Handling Raw Materials and Merchandise at Ports and other Large Centres of Traffic	447
Notes from the United States	436	Colonial and Foreign Engineering Projects	448
Notes from the North	437	High-Pressure Air-Compressors (*Illus.*)	448
Notes from South Yorkshire	438		
Notes from Cleveland and the Northern Counties	438		
Notes from the South-West	438		
The Status of the Engineer	439		

With a Two-Page Plate of the GENERAL ARRANGEMENT OF MACHINERY IN THE TWIN-SCREW MOTOR-SHIP "ABELIA."

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 3, in the meeting hall of the Institution of Civil Engineers, Great George Street, Westminster, S.W., at 6 p.m. The Thomas Hawksley Lecture on "The Gas Engineer of the Last Century" will be delivered by Mr. Harry E. Jones, Member.

THE SOCIETY OF ENGINEERS.—Monday, November 6, at 5.30 p.m., at Caxton Hall, Westminster, S.W. A paper entitled "Heating and Ventilating Private Dwelling Houses," by Mr. C. T. Alfred Hanssen, F.S.E., Assoc.M.Inst.C.E., will be read.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS, INCORPORATED.—Tuesday, November 7, at the Institution of Electrical Engineers, Victoria Embankment, London, at 2.30 p.m., when the following paper will be read and discussed:—"The Economical Signalling of a Colonial Railway," by Mr. A. C. Rose, Associate Member.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 7, at 5.30 p.m. Address by Sir Maurice Fitzmaurice, C.M.G., the President, and presentation of medals awarded by the Council.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, November 7, at 7 p.m., when a paper will be read on "The Utilisation of Coal," by Mr. J. D. McArthur, Member.

THE RÖNTGEN SOCIETY.—Tuesday, November 7, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Presidential Address by Captain C. Thurstan Holland, M.R.C.S.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, November 8, in the Hall of the Royal Society of Arts, John Street, Adelphi, W.C., when a paper by Mr. A. Ludlow Clayden, entitled "Electrical Car Equipment," will be read. The chair will be taken by the President, Mr. L. A. Legros, at 8 p.m.

THE FARADAY SOCIETY.—Wednesday, November 8, at the Institution of Electrical Engineers, Victoria Embankment, from 5.30 p.m. to 7 p.m., and from 8.30 p.m. to 10.30 p.m. A general discussion on "Refractory Materials." Sir Robert Hadfield, F.R.S., President, will take the chair and deliver an introductory address.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 9, at 8 p.m. The Eighth Kelvin Lecture, entitled "Some Aspects of Lord Kelvin's Life and Work," will be delivered by Mr. A. Russell, M.A., D.Sc. The premiums for papers read or published during the last session will be presented.

THE OPTICAL SOCIETY.—Thursday, November 9, at 8 p.m., at the Rooms of the Chemical Society, Burlington House, Piccadilly, W. The following paper will be read and discussed:—"Some Notes on Glass Grinding and Polishing," by Mr. James Weir French, B.Sc.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 3, 1916.

THE STATUS OF THE ENGINEER.

VISITORS to China in the middle of the eighteenth century found there an indigenous civilisation in no material regard inferior to that of Europe at the same date. One hundred and fifty years later China seemed to us semi-barbarous at best. It was known as the land of cruel and vindictive punishments, as the country where means of communication were bad, or at best indifferent, and as the home of a very ignorant and superstitious population. At the earlier date, however, it compared in all these respects not unfavourably with Europe. Here criminals were sentenced to death or to barbarous floggings or mutilations for what would now be considered quite minor offences. Indeed, the punishment of pressing to death for refusals to plead was only abolished in 1774. In respect of means of communication European roads, in the middle of the eighteenth century, were little, if at all, in advance of those of China, though our ships were no doubt superior, but if Europe was ahead in seacraft, China held the lead in many other departments of industry. As to ignorance and superstition, it is only necessary to recall that there was an execution for witchcraft in Posen as late as 1798. The extraordinary change in the relative position of the two civilisations, which was effected in the course of a little over a century, has unquestionably been directly due to the work of the engineer in making practical application not merely of his own discoveries, but of those of the physicist and chemist. For centuries before the rise of the engineer the lawyer and the cleric had had unchallenged control both of education and of legislation, and the results can hardly be considered as edifying.

According to the Roman law, the three essentials to civilisation are roads, more roads, and still some, and until the engineer improved the means of communication both of ideas and materials, progress was little or nothing. A State must maintain order, and when crime is difficult to detect and criminals find escape easy, it attempts to suppress crime by the savagery of the penalties imposed. Humane men have undoubtedly existed in all centuries, but until means of communication were improved the criminal laws of all countries remained monuments of inhumanity, and had not steam been called on to do the slave labour of the world, serfdom and slavery would have persisted indefinitely. During the whole of the period in which the engineer has been changing the face and thought of the world he has been denounced as a gross materialist by the classes who have produced the bulk of our politicians. Whilst, however, in conversation and in print they may, with Mrs. Blimber, have pined to share Cicero's retirement in Tusculum, they have in practice shown no reluctance to secure their own share of the benefits resulting from our increased control over the powers of Nature. Indeed, they have been wise enough to recognise that to secure a hearing for their protests it was necessary to keep within protesting distance.

In spite of the preponderant part played by the engineer, his position in popular estimation stands far below that of the politician, whether lawyer or lay. An American economist has estimated that the value of Bessemer's invention to the world at large cannot be put at less than 100,000,000*l.* per annum, yet his name is all but unknown to the general public. In fact public opinion would to-day almost seem to incline to the view that the navvies built our railways by their unaided efforts, and that the great ocean liner is the result of the undirected labour of our shipyard operatives. They do not realise that every great engineering work has had to exist in the minds of the engineers responsible, previous to its incorporation in material form.

The divorce of the engineer from public affairs and the minor place he occupies in popular estimation is, we observe, causing disquietude on the other side of the Atlantic. In a paper recently read before the Society of Engineers of Western Pennsylvania, Mr. J. A. L. Waddell, the well-known American bridge engineer, deplores the condition of affairs in the United States and casts about for some efficacious remedy. As illustrating the present position of affairs, he reports that in one of the richest and most active counties of the middle west a lawyer has been appointed to the post of county engineer because it was held that the post must be filled by a politician. The actual engineering work has therefore to be done by deputy, thus reproducing the characteristics of our own national services, where it has been common to appoint mere clerks as heads of departments, even when these were concerned with highly technical matters. The official view is that expert knowledge is unnecessary in such cases, as trained assistants can be secured to do the work, whilst the nominal chief signs the inevitable forms. As Lord Sydenham puts it, the results of such a system are that the man who knows all about some subject has to refer to and be overruled by someone who knows nothing whatever about it. The working of the system as exemplified during the recent times of stress has been more instructive than edifying.

Mr. Waddell further observes that in America, when two vacancies recently occurred on the Interstate Commerce Commission, which has to deal with some highly technical questions, the suggested appointment of an engineer to one vacancy was promptly rejected. The usual method of expending municipal finances in America is, he proceeds, also glaringly absurd. The responsibility has been left "in the hands of a horde of politicians," with the result that the work, both of development and maintenance, has been "wretchedly and dishonestly done." In fact matters became so bad that attempts have been made to establish a commission form of city government, but here again, he states, failure followed because the posts continued to be filled with politicians.

It would be undoubtedly greatly to the advantage of the public did engineers more frequently engage in public affairs. The difficulties in the way are, however, considerable. A barrister's whole training is in the direction of teaching him what can be said on a subject rather than what should be said. He is as ready and able to argue on the one side of a case as on the other, and thus finds little

difficulty in accommodating himself to the necessities of party politics. Special gifts in the matter of estimating evidence are sometimes claimed for him, but in this respect he certainly stands below the engineer, who fixes, say, the supporting power of a doubtful foundation, or of the doctor, who discriminates between the early stages of, say, typhus or typhoid fever. On the other hand, the very readiness with which a barrister will argue either side of a cause promotes a judicial attitude of mind which in certain positions has undoubted advantages. An experienced barrister, even if sufficiently well educated to understand their futility, could listen with no signs of impatience to the contentions of a perpetual motion crank, whilst an engineer would refuse to waste time in hearing him, even in return for a fat fee.

Another claim quoted by Mr. Waddell is that a lawyer's training promotes straight thinking and logical reasoning. It is, however, difficult to believe that any lawyer ever thought more logically or clearly than, say, James Watt. In fact, Nature will stand no muddling through, and a lack of straight thinking inevitably involves heavy penalties. It was, moreover, an eminent lawyer, not an engineer, who averred from the Bench that there could be no question as to the reality of witchcraft, as its existence was affirmed in Holy Writ, and the (lawyer's) wisdom of all nations had provided penalties for its practice.

The lawyer or the politician, in appealing to the public, always endeavours to proceed logically from some plausible general principle. The engineer, on the other hand, can rely only to a limited extent on deduction from first principles. He is never quite certain that a proposed new departure will be successful until his conception is actually and happily embodied in stone or metal. More than any other class of the community he is daily reminded of the truth of Samuel Butler's aphorism that the art of living consists in drawing sufficient conclusions from insufficient premises. This puts him at a serious disadvantage in gaining a public hearing for his views. His speculations are policies and not creeds. If it be a question of State or company-operated telephones, for example, the politician will start from some such sonorous thesis as that "Public services must not be exploited for private profit." A high-sounding hypothesis of this kind serves as an excellent text for eloquent sermons in which the deductions from it are logically developed. The engineer approaching the same subject forms no hypothesis at all, but painfully and persistently seeks to learn how the matter actually works in practice. Is the service better in the one case than the other? In which case is there the greater readiness to adopt improvements and encourage experiment? In which service does the young man of exceptional ability most readily rise to a position in which his talents may best serve the interests of the public? When, however, the engineer endeavours to bring before the public the results of such an inquiry, he merely tires people. Nothing, again, is more touching than the faith of a certain class of politicians in statistics. These they think themselves capable of understanding, whilst on technical matters they have to admit their ignorance. As a natural result, in our public services the creative departments are commonly starved, whilst the clerical and statistical sides are being constantly increased.

Much attention has recently been paid in the States to the valuation of public utilities, and on this head no one is so qualified to deliver an authoritative opinion as the engineer, who has been responsible for their creation. Dr. Waddell, however, quotes an American economist, Professor Gray, as asserting that the engineer is in no way fitted to discuss such questions as value and wealth. On the other hand, the ignorance of professional economists on these subjects is a standing marvel to the engineer. To simplify his subject the economist, so to speak, deletes the part of Hamlet from the play. The creation of wealth he attributes solely to the joint efforts of labour and capital, omitting all reference to the predominant part played in the process by mind.

Mr. Waddell takes the view that inadequate professional knowledge is at least partially responsible for the relatively low standing of engineers in the public estimation. Experience in this country hardly bears this out, as we have had many instances of engineers attaining positions of great eminence whose professional qualifications were considered far from high by those most competent to judge. Readiness in speech and excellence of style in writing often, so far as public eminence is concerned, go far to counteract more material deficiencies. Dr. Waddell is certainly correct in insisting on the importance of a thorough study of the English language, but readiness, which is equally valuable, is a gift of Nature, hardly achievable by art. There are many who can give the correct solution to difficult professional problems, but they resemble the White Queen, who could only do addition if she got time. A hesitating but honest answer commonly raises doubts as to a man's competency, where a more assertive but possibly more ignorant engineer might create an excellent impression.

It would be undoubtedly greatly to the advantage of the public were engineers to take a larger part in the direction of affairs, but Mr. Wells is probably correct in concluding that the politician and lawyer will rule us to the end of time. So far as he is individually concerned the engineer has his compensations. The contest with Nature has an interest of its own, and each advance he makes remains as something acquired for humanity to the end of time. The details of the struggle may not appeal to the uninitiated. Those who would follow with interest the story of the early struggles of a legal luminary would be merely bored by a detailed description of the strife in which engineers step by step wrest from reluctant Nature yet another small fraction of the energy latent in a pound of coal. "Romance" may, as Kipling says, have "brought up the nine-fifteen," but the fact hardly receives popular appreciation.

NITROGEN OXIDES FROM AMMONIA FOR THE LEAD-CHAMBER PROCESS.

It is rather remarkable that some details of processes for the oxidation of nitrogen, worked out in Germany, have been published since the beginning of the war. When the war broke out all the saltpetre available in Germany was requisitioned for the use of explosive works, which, of course, want nitric acid. But nitric acid is indispensable as well for the manufacture of sulphuric acid on the old lead-chamber method, which was still the most extensively used method in Germany. Deprived of one of their raw materials, saltpetre, those works would have had to shut down unless they could make nitric acid without using saltpetre. Two other ways of making nitric acid or nitrogen oxides had been open for some time. The one, about which much has been written, is the oxidation of atmospheric nitrogen with the aid of the high temperature of the electric arc; that method has been successfully developed, but arcs are current wasters, and thus nitric acid and nitrolim industries only prosper in districts of cheap hydro-electric power. The other method, generally identified in recent decades with the name of Ostwald, was the oxidation of ammonia. The principle was well understood, technical applications of several processes were spoken of, but particulars were not published. In *Metall und Erz* of January 22, 1916, however, the director of some sulphuric acid works at Stolberg, near Aachen, in Rhenish Prussia, gave some particulars of the method he had introduced in his works. The first point of interest is that the gaseous ammonia is burnt by contact with red-hot platinum, and that the nitric oxide and other nitrogen oxides formed are sent directly into the lead chambers, there to effect the oxidation of the sulphur dioxide (from the roasting furnace) to sulphuric acid. Thus nitric acid is, in the new method, not first made and decomposed again into the oxides to oxidise the SO_2 in the chambers, but the nitrogen oxides resulting from the combustion of ammonia are at once utilised for the oxidation. The particular process applied is that of Frank and Caro. Mr. Schüphaus, who is an engineer, describes first the original plant, and then some improvements which were adopted in his works.

In the original plant the raw material started with was ammonia liquor, which was supplied in cylindrical receivers on trucks. The liquor was run into tanks—old boilers—fixed in the ground below the works flooring. From these tanks the liquor was forced by compressed air into mixing tanks in which the liquor and so much milk of lime were mixed under lively stirring that the liquid contained 2 or 3 per cent. of ammonia. This liquid was then pressed into the top of a column apparatus or dephlegmator, consisting of six compartments, while steam at 0·3 atmosphere pressure entered into the bottom compartment. The gaseous ammonia escaped above, while the water flowed back into the dephlegmator. The gas flowed through two coolers in series containing a large number of vertical iron pipes, the ammonia passing through the pipes. The gaseous ammonia then entered two vessels half full of caustic soda lye, to be washed and freed of sulphuretted hydrogen, phenol and other impurities; a false bottom separated the gas current in these vessels into a large number of fine gas jets, to secure intimate contact with the caustic soda. Leaving these washers, the gas was sent into a gas holder of small capacity, 5 cub. m. The whole arrangements, liquor feed, steam pressure, cooling, &c., were so regulated that the liquid should boil only in the lower compartment of the dephlegmator, not in the top compartment, that water vapour should be condensed in the first cooler, but the temperature remain sufficiently high there to facilitate the evaporation of the ammonia, and that the gas holder should serve also as a pressure regulator to balance fluctuations in the ammonia pressure.

From the gas holder the gaseous ammonia was, and is, sent into the "combustion elements" apparatus, of which three were installed for the lead chambers of works producing 10,000 tons of a sulphuric acid of 60 per cent. per year. Ammonia and air are mixed in correct proportions (secured by fans and by diaphragms and valves in the lines) and sent into the mixing chamber of a combustion unit, passing first through several layers of iron wire netting, which is provided to make the mixture uniform; the gases then strike the horizontal net of platinum gauze which acts as catalyst. This gauze is exceedingly fine, almost like a silk texture, and is held on either side by a pair of brass bars, silvered on their surface; the brass bars are connected with the current leads, which introduce currents of 125 or 150 amp. at 20 or 25 volts. At the temperature of the dark-red glow of the platinum (about 700 deg. C.) the ammonia is completely burnt to nitric oxide and water. The gases pass upward into a pyramidical hood of iron (lined inside with aluminium), and through an aluminium elbow into the pipe (common to the three units) entering the lead chambers. The aluminium lining is required lest iron oxide drop down upon the platinum gauze. The pipes are of iron, the fans of aluminium. The flanges in the ammonia conduits are packed with rubber, or oil and asbestos, or with a material called klingerit; to keep the top of the dephlegmator gas-tight, a layer of 5 mm. thickness of a very stiff paste of minium and oil is applied. To prevent saturation of the water of the gas holder with ammonia, oil is poured on the water; a slight percentage of ammonia in the water is desirable to prevent freezing; the oil also avoids losses of ammonia by evaporation from the annular space between the bell and the body of the gas holder. In the combustion apparatus the space just below the platinum gauze is water-jacketed, lest any ammonia should be decomposed by the heat before being burnt; otherwise nitrogen would escape unoxidised.

So far the original plant. There was trouble with the lime, which clogged the ports in the dephlegmator, and for this and for other reasons liquid ammonia of 25 per cent. was substituted as raw material for the crude liquor. The plant was thus much simplified, the mixing tanks and the soda washers, as well as the settling tanks (in which the cooling water was cooled and clarified for reuse), becoming dispensable. The attendance was minimised, moreover, the ammonia feed alone requiring occasional adjustment by the man looking after the lead chamber. The Berlin-Anhaltische-Maschinenbau-A.G.—which manufactures and sup-

plies the whole apparatus above described—has recently added a valve which automatically controls the bell of the gas holder, so that there is no need for any attendance at all. The use of liquid ammonia has another very essential advantage. When the liquor was used, the dephlegmator could deal with 5 cub. m. of liquid per 24 hours, which meant that the 2·5 per cent. liquor could yield 125 kg. of gaseous ammonia per day. By starting with liquid ammonia of 25 per cent. the capacity was raised tenfold, to 1,250 kg. Now that amount of ammonia suffices to keep several lead-chamber systems going, and one combustion unit has proved sufficient for producing 10,000 tons per annum of sulphuric acid of 60 per cent.

The nitrogen oxides were first introduced into the connection between the Glover tower and the main chamber, in order to become well mixed with the sulphurous oxides. With this arrangement, however, a long iron pipe (9 m. in length) was required for the nitric oxide, and the iron was attacked and stoppages arose. To avoid this the combustion units are now mounted close to the main lead chamber, and the iron pipe from the units ends in an earthenware pipe, which penetrates by about a foot into the chamber, being inclined, so that any condensed liquid will not come in contact with the walls of the chamber. Trouble has occasionally arisen from impurities in the liquid ammonia; although this material is very good on the whole, there is sometimes a little spongy iron oxide or iron hydroxide in it, which clogs the ports in the dephlegmator. In such a case the dephlegmator has to be taken to pieces, which causes an interruption of several hours. But as one dephlegmator is sufficient, such contingencies need not be feared when two such apparatus are installed.

For some reason the works were also disturbed by temporary failures of the electric current. Then the fans would stop, the gases from the lead chamber would rush back and would poison the platinum gauze, which had to be thoroughly cleaned with hot hydrochloric acid to become catalytically effective again. To obviate this disturbance a flap valve has been inserted into the air line; this valve (of thin sheet iron) floats as long as the fan is going and is sending air into the combustion chamber; when the fan stops, the valve closes, but the ammonia feed continues and keeps back the gases from the lead chamber. To meet other failures part of the nitrogen oxides is sent through a small tower-apparatus in which sufficient nitric acid is prepared to help the plant over periods of disturbance.

Mr. Schüphaus mentions several other technical points of interest. As regards the economy of the process, he merely states that the amount of nitrogen wanted in the new process keeps within the limits of the nitrogen consumption on the former nitric acid working. Things may not be altogether satisfactory and as simple as they appear; but it is interesting to have such an account on the working of a new process. We hope to be able to give, later on, further particulars of the results obtained.

THE ACCIDENT TO THE QUEBEC BRIDGE.*

By Frank W. Skinner.

Transporting Suspended Span.—A study of tide tables shows that the average range of tide is about 16 ft., with a maximum variation of about 6 ft. and 2 ft. respectively at the high and low tide levels at the bridge site and at Sillery. The tidal current at the bridge site is from 6 to 7 miles per hour, one hour before high tide. It is reduced to about 5 miles at high tide, and reverses about one hour after high tide. At this period there is, before and after the change, an interval of about one hour during which the current does not exceed 3 miles per hour. It was planned to transfer the weight of the span from the scows to the cantilever arms at this time.

An actual range of 15 ft. was necessary to drain the scows of their water ballast and to lift the suspended span from its falsework support. As suitable tidal conditions were expected to occur for four or five successive days on and after September 11, the time of the transfer was fixed for that date, subject to the indications of the daily Government meteorological reports, to barometric observation, and to the appearance of the sky at the bridge site. It could be predicted with sufficient accuracy that wind exerting a greater pressure than 2 lb. per square foot would prevent the beginning of operations on an unsuitable day, but wind of less intensity would not cause serious difficulties.

Suspending and Lifting Suspended Span.—In accordance with this programme, the suspended span was successfully towed to the site near the end of the flood tide on the morning of September 11. It was securely moored between the vertical trusses extended from the anchor arms, and adjusted to the proper position. Connections were made to the hoisting apparatus, and the weight was gradually transferred to the cantilever arms by the operations of the hydraulic jacks and the falling of the tide, which released the scows and permitted their removal. The span was thus suspended at a height of about 20 ft. in the clear above the water, and was supported at each corner on a massive pedestal with an adjustable bearing on the hoisting apparatus installed at the end of the cantilever arm above (see Fig. 1, page 438).

The hoisting apparatus consisted of two overlapping yokes in vertical planes transverse to the bridge axis (see Figs. 6 and 7, page 443). Each yoke consisted of a top and bottom box girder with corresponding ends connected by pairs of vertical links. In the upper yokes the vertical links were rigidly connected to both girders, and the whole yoke was immovable. In the lower yoke the bottom girder had fixed pin connections to the suspension or hoisting links; these passed between the webs of the lower box girder in the upper yoke, and had movable pin connections to it and to the upper girder of the lower yoke.

Hydraulic jacks engaging the top flanges of the lower girder of the upper yoke and the bottom flanges of the upper girder of the lower yoke were operated to separate these girders, thus lifting the lower yoke and its burden a distance equal to the 2-ft. working stroke of the jacks. The connections at the top of the suspension links of the lower girder were then shifted from the upper girder of the lower yoke to the lower girder of the upper yoke and the jacks slacked off, lowering the upper girder of the lower yoke to its original position. Then it was again connected to the hoisting links of the lower yoke, jacked up again, released, lowered, and so on, moving back and forth the same distance, and lifting the suspended span 2 ft. at each operation.

About 73 lifting operations were required to hoist the suspended span to the necessary elevation for the permanent vertical eyebar links, already connected to the end lower chord of the span, to register at their upper ends with the connections provided for them at the ends of the top chords of the cantilever arms. In this position the permanent connection pins could be driven through them and the chords, and the jacks be finally released, leaving the suspended span in permanent connection with the cantilever arms. After this the hoisting apparatus could be easily removed. The track stringers and floor of the suspended span, which had previously been omitted to diminish the weight hoisted, could then be assembled, virtually completing the construction of the great bridge.

The Accident.—About 1 a.m., September 11, at low tide, the valves in the bottoms of the scows under the suspended span at Sillery were closed, and the rising tide floated the span from its support at about 3.40 a.m. Work was suspended until daylight, and at 4.30 the span was towed clear of the falsework, and swung about 90 deg. to a position transverse to the axis of the river. At 5.20 it commenced its three-mile trip to the bridge site, with two tugs ahead pulling with the tide, and five tugs behind generally backing water to retard its motion. Another large tug was held in reserve for emergency.

The trip was made in about 1 hour and 10 minutes; about an hour later the span was moored to the vertical trusses. At 7.45 the tugs were all cast free from the scows, and before 8 o'clock all the hoisting links were attached to the lower or lifting girders and began to take the weight from the scows. At 8.50 the operation of the hoisting jacks commenced, the span cleared the scows at 9.22, and at 9.30 all the scows had been moved clear of the span, which was left hanging about 20 ft. clear of the water and fully supported from the cantilever arms.

The most critical and difficult operations were thus completed with entire safety and in exact accordance with the programme and calculations. Nothing important remained but a few hours of routine work, with thoroughly tested apparatus and skilled labour and superintendence, under official technical supervision. The day was calm and fair, and all the plant was working satisfactorily.

The jacks were operated about one hour longer, making four or five 2-ft. lifts, when work was suspended an hour for breakfast; many of the thousands of prominent engineers and other distinguished guests had left the bridge site. After the work was resumed another 2-ft. lift was taken, the hoisting links were connected to the lower jacking girder, and the jacks were being backed off. No wind was blowing, no machinery of any kind was in operation on the bridge, and the suspended span was about 35 ft. above the surface of the water, when at 10.46 a.m. a loud report was heard and the south-west corner of the suspended span was displaced from its bearings, moved off from its support, and slowly settled into the water.

Violent horizontal motion was observed in the yokes at the other three corners of the span, but the bridge remained seated intact for several seconds, while the west truss sank lower and lower, crippling the transverse bracing and warping and distorting the east truss. This was pulled into an almost horizontal position at the south end, the north end remaining nearly vertical, as shown in Fig. 3 on page 306 *ante*, taken while the failure was in progress. The south-east corner of the bridge then became displaced from its bearing on the hoisting girder, allowing the entire south end of the bridge to drop and pull the north end bearings clear of their supports. The entire span immediately sank to the bottom of the river in water more than 200 ft. deep.

The falling span caused minor injuries to the supporting yokes and caused them to swing violently through pendulum arcs of many feet. Several of the working platforms on the yokes were destroyed, and 13 of the workmen there and on the suspended span went down with the latter and perished. The few others that were injured will recover.

Other Results.—The weight of the suspended span had deflected the ends of the cantilever arms more than 8 in., and when this load of more than 5,000 tons was suddenly released, the cantilever trusses recoiled to beyond their former positions, violently upsetting many people standing on them, and throwing considerable quantities of loose material into the river below. A very careful official inspection has failed to disclose any sheared rivets, bent plates or buckled members, distortion, displacement or other injury of any kind to any part of the remaining superstructure or substructure. The enormous strength and the excellence of material, design and construction of the structure have been demonstrated by its enduring the terrific sudden stress that is estimated to have been at least 100 per cent. greater than the maximum working stress provided for in the design.

Inspection and Conclusion.—Every facility was immediately afforded for the most thorough investi-

* We have already, in our issues of September 16, 22 and 29, and October 6, 13 and 27, published a general description of the methods adopted for placing in position the central span of the Quebec bridge, and have given the conclusions arrived at by the investigating engineers as to the immediate cause of the disaster and the sequence of events following the primary failure. Mr. Skinner's comprehensive description of the methods adopted to ensure safety in the unprecedented feat of transporting and hoisting a span of this magnitude will repay careful study, as will his very detailed relation of the successive stages of the accident, and of the observations subsequently made. The span weighed some 5,000 tons, and was erected on piling driven into the foreshore of Sillery Cove, a few miles down-stream of the bridge site. Mr. Skinner has prefaced his article with a description of the general character of the bridge and of the methods adopted for its erection. As these are already familiar to our readers we reserve them for the present and commence with his account of the transport of the central span.

gation of the structure and the cause of the accident by the Government engineers, the contractors and representatives of the technical Press, and the evidence secured is conclusive that the accident was entirely due to the sudden failure of the massive steel casting in the south-west bearing on the lifting girder. A summary follows of the evidence on which this conclusion was unanimously reached, and indisputably proves that the design, methods, materials, workmanship and erection operations were unimpeachable, and that the failure of the

Details of Erection, Plant and Methods.—The suspended span was provided with a temporary universal joint bearing at each end of each lower chord. It was assembled on these bearings at Sillery; the bearings were relieved of load when the span was transferred to the scow, and again put in service when they were seated on the girders of the hoisting apparatus at the bridge site. The functions of the universal joint, inserted between the top of the lifting girders and the corners of the suspended span, were as follow:—

two forged steel pins. The upper casting was a simple pedestal, cruciform in plan, with a 3½ ft. by 4½ ft. horizontal upper surface bolted to the cover plate on the bottom flanges of the lower chord of the suspended span at the panel point. It had a half-hole bearing for an 8-in. horizontal pin transverse to the bridge axis, which was seated on a similar solid steel casting with a half-hole bearing on the underside on a 9½-in. pin, 54 in. long, parallel to the bridge axis. The lower pin took a half-hole bearing on the upper side of a 1½ ft. by 5½-ft. cast-

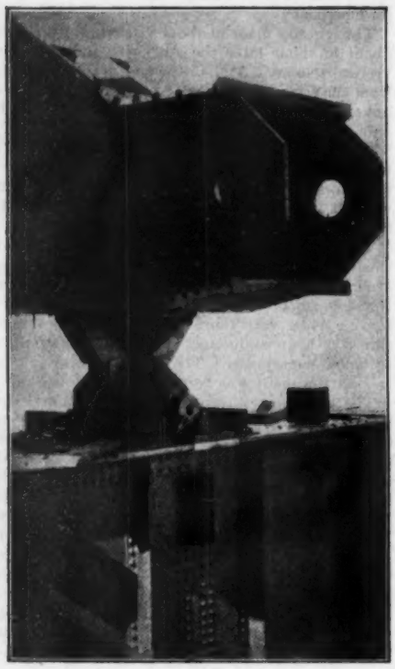


Fig. 3.

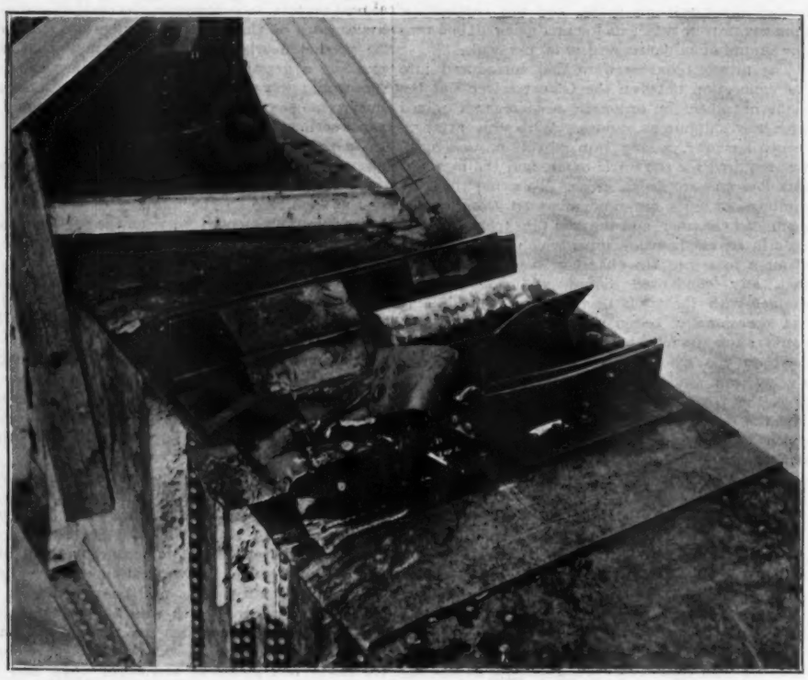


Fig. 4.

high-class steel bearing of exactly the type most frequently used for similar bearings in permanent structures could not have been foreseen.

In accordance with these conclusions the contractors have voluntarily assumed full responsibility and have announced their intention to rebuild and re-erect the suspended span with the greatest possible speed. It is significant of the absolute confidence of the Government officials, engineers, contractors, and all associated with the work that, except in the rocker castings, no deviations will be made from the original plan. Exactly the same design, methods, operations, &c., will be repeated, since there is no point which is considered imperfect or susceptible of improvement with present facilities.

The design of the rocker castings between the lifting girder and the suspended span will probably be changed—more for sentimental reasons than otherwise—as it would not look reasonable to trust a traitor the second time. But, apart from this one detail, no others are at this time expected to be altered. Notwithstanding the unprecedentedly high price of steel in the United States, which is about twice as much as when the original contract was awarded, orders have been placed for the new steel. It is confidently expected that it will be delivered in time for fabrication this winter and spring, so that the span may be erected and the bridge completed during the season of 1917.

Owing to the great depth of the river, the high velocity of the water, the range of tides and the important navigation maintained in the river channel, it would probably be impossible to salvage the wrecked span. As it is so far below the surface as to offer no possible obstruction to navigation and little to the regimen of the river, it will probably remain undisturbed adjacent to the pitiable wreck of the south cantilever arm of its predecessor, which has rested on the river bottom since the fall of 1907.

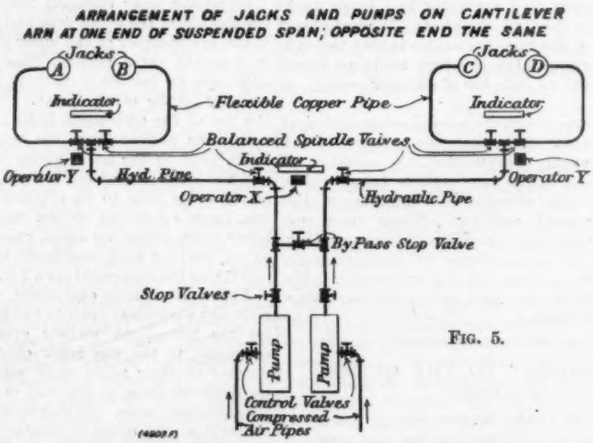


Fig. 5.

First; to provide for longitudinal displacement, due to the stretching out of the span, by sliding on the lower pin, and for vertical displacement, by rotation around the transverse pin, as the span was lowered on the sand jacks during the swinging operation at Sillery.

Second; after the load of the span had been transferred from the barges to the hangers at the bridge site this joint provided for vertical displacement, due to deflection of the span at the time the load was transferred from the barges to the lifting girders, and also for longitudinal and transverse displacements, due to horizontal forces that might be exerted by mooring lines, wind, &c.

Each bearing, which was proportioned for a working load of 1,500 tons, including 20 per cent. impact, was made with three steel castings and steel bedplate, bolted to the top flange of the double web lifting girder (see Fig. 3 annexed).

After the bridge span was seated on the transverse scows, with the lifting girders temporarily suspended from it by vertical links engaging angles riveted to the girder and to the span, the intermediate bearing castings were adjusted to absolute centre position by means of vertical steel plates bolted to the web of the lower casting. These had vertical edges bearing on finished surfaces of the transverse web of the intermediate casting, thus centring it and the superstructure directly over the webs of the hoisting girders.

The specifications required the highest quality of steel, the castings were designed for conservative working stresses, were carefully inspected, and accurately finished in the usual manner to detect

any imperfections or concealed flaws. The castings were installed under the span on the erection falsework at Sillery and there received loads augmented by the temporary track and erection plant used on the span, They were thus subjected to impact and static stresses several hundred tons in excess of those developed during the hoisting operations. These increased stresses were sustained without any evidence of distress or injury for a period of from five to six weeks, and the castings endured the regular stresses for several hours after the hoisting was commenced, before the accident occurred.

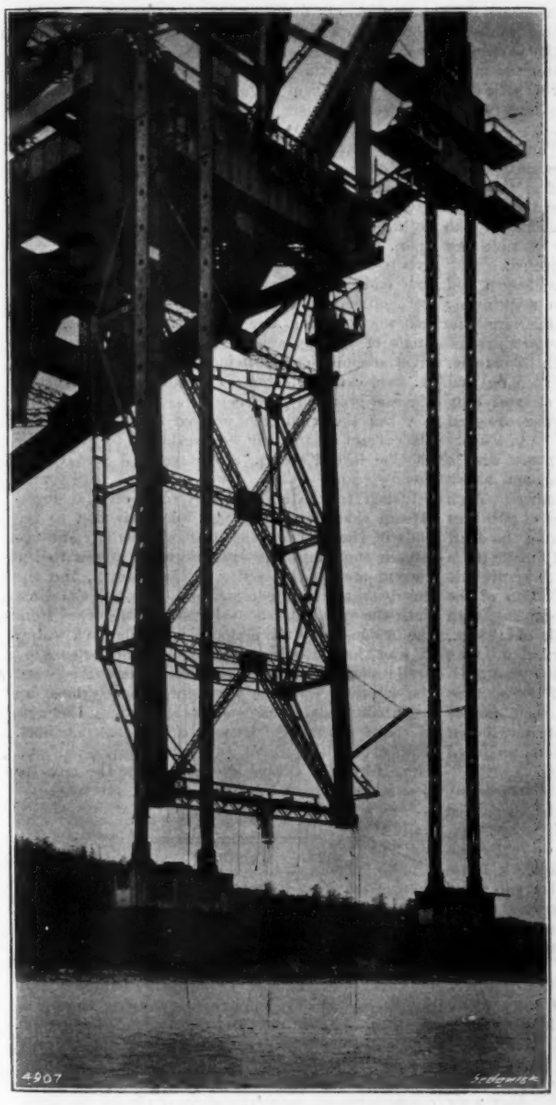


FIG. 6.

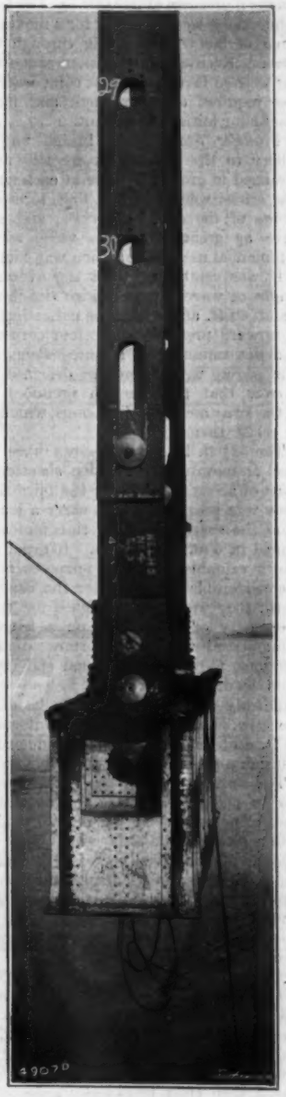


FIG. 7.

Lifting Girders.—The lower castings of these adjustable bearings were seated on girders having two webs 7 ft. deep and 25 ft. long, connected by flange cover plates and a pair of transverse vertical diaphragms. Between these diaphragms were riveted massive vertical stub links projecting above the top flanges of the girders and bored to receive the 12-in. pins connecting them to the hoisting links suspended from the cantilever arms. These girders, called the lifting girders, are the lower girders in the lower yokes. The upper girders in the upper yokes are similar to them (Fig. 7, above).

Hoisting Yokes.—The principal items of the hoisting apparatus are the four sets of yokes which, as before stated, were located at each corner of the suspended span at the site and transferred its weight to the cantilever arms. Each set consisted of a pair of overlapping yokes made with horizontal top and bottom transverse girders and pairs of vertical suspension members connecting them at both ends. The upper girders, called supporting girders, closely resembled the lifting girders already described, and took bearing on the ends of the top chords of the cantilever arms. The supporting girder was seated on a pin bearing, on the top of the cantilever, parallel to the axis of the bridge, which provided for motion, or rocking, of the supporting girder transverse to the axis of the bridge. The vertical hangers were connected to stub hangers, riveted between the webs of this girder, by pins perpendicular to the axis of the bridge, which provided for motion in a longitudinal direction. This was a universal joint, but of a different character from that on the lifting girder, as the latter joint had other functions to perform when the span was swung at Sillery.

The lower girder of the upper yoke, called the lower jacking girder, was longer than the supporting girder, and received between its webs and between its pairs of transverse diaphragms the lower ends of the vertical suspension members, which were rigidly attached to it and to the supporting girder, forming a fixed rectangular framework.

The lower yoke was also made with upper and lower transverse girders in the plane of the girders of the upper yoke, and with the upper jacking girder always above the lower jacking girder of the upper yoke. The upper and lower girders of the lower yoke were connected by pairs of vertical suspension links at each end, which formed the adjustable hoisting links. While in hoisting service these links were connected to the lifting girders by pins through long, vertically-slotted holes in the former and through round holes in stub links riveted to the ends of the lifting girders.

Each hoisting link was made of two 30 in. by 1¼ in. steel plates, about 30 ft. long, with 12-in. holes spaced 6 ft. apart, making a set with a combined cross-sectional area of 270 sq. in. for each cross girder. The upper ends of the links passed between the double webs of the double transverse diaphragms of the two jacking girders at floor level in the ends of the cantilever arms, and were connected to the transverse diaphragms in these upper and lower girders successively by 12-in. pins engaging the pin-holes in the hoisting links and engaging vertically slotted pin-holes 2 ft. apart in the transverse diaphragms.

Operating Yokes and Jacks.—At the beginning of operations the lifting girders received the universal joint bearings at the ends of the suspended spans and were connected to the upper jacking girders that constituted the upper girders of the lower yokes. The upper and lower jacking girders were then separated on each corner of the bridge by two 1,000-ton hydraulic jacks with universal bearings engaging their adjacent flanges and by counterbalanced screw jacks between them, which were intended to follow up the operation of the hydraulic jacks and provide supplementary support for the upper jacking girders in case of any possible failure of the hydraulic jacks (see Fig. 2, page 438).

At this time the hoisting links were not connected to the lower jacking girders which formed the bottom girders of the upper yoke, and their lower ends hung slightly out of the vertical to clear the suspended span. When the latter was in position the lower ends of the hoisting links were pin-connected to the lifting girders through long vertically slotted holes, enabling the connections to be made regardless of the exact vertical position of the suspended span.

During the operations of hoisting all jacks were simultaneously pumped up to full stroke, 2 ft., and the hoisting links were pin-connected to the diaphragms in the lower jacking girders. The jacks were slacked off to release the pins through the slotted holes in the diaphragms of the upper jacking girders. The pins were then removed, and the jacks slacked to the end of their stroke, lowering the upper jacking girders, unloaded, to their bottom position. They were then again pin-connected to the hoisting links and the jacks operated to lift the span 2 ft. more, and so on, the operation taking from 10 to 15 minutes. The pins for both pairs of hoisting links, in both the upper and lower jacking girders, at each corner of the span—*i.e.*, 4 pins at each corner, or 16 for the entire span—were mounted in pairs on 3-in. horizontal bars suspended with counterweights from above, so that they were easily and quickly handled in removing and withdrawing them.

After each series of 15 operations one of the 30-ft. sections of the hoisting links would be released and removed. Finally, when the bridge attained approximately the required elevation and was sustained by the lower section of the hoisting links, the permanent vertical suspension eyebars attached to the end lower chord pins of the suspended span were to be pin-connected to the ends of the cantilever arms.

Hydraulic Jacks.—The rams in the eight hydraulic jacks were made of such diameter that the estimated load would be lifted under a working pressure of 4,000 lb. to the square inch, the actual observed pressure during the lifting being about 3,600 lb. The strength of the jacks, piping and connections was made to resist a pressure of 6,000 lb. to the square inch, so as to obtain, if necessary, a margin of 50 per cent. over the figured working pressure by increasing the water pressure from 4,000 to 6,000 lb. This increase in the strength of the jacks, piping, etc., involved very little expense, and it was considered a wise expenditure to have a considerable margin above the figured pressure. The

jacks were tested at the shop to a pressure of 6,300 lb., and the entire apparatus, after installation at the bridge, to a pressure of about 5,000 lb.

The working load was 1,200 tons, shop-tested to 1,250 tons, after which the jacks were pressure-tested in the field to 1,000 tons by operating them in position when the hoisting links were pin-connected to both upper and lower jacking girders. During erection they were actually operated at a pressure of 3,600 lb. per square inch. The supplementary jackscrews were counterweighted, so that they could be easily and rapidly operated by one man.

Pressure Pumps.—The hydraulic jacks were operated by four 18-in. and 2-in. by 16-in. single cylinder pumps independently driven by air at 100 lb. pressure. The pumps were provided with safety valves set to indicate the required speed and were controlled by extension valve stems. In general, the starting and stopping of the apparatus was effected by opening or closing the air valves at the pumps, so as to relieve the piping of hydraulic shock. The operator at "X," (see Fig. 5, page 442) by means of his two valves and indicator, regulated the relative position of the two corners of the bridge during the jack-stroke of 2 ft., and the operators at "Y," through their two valves and indicators, regulated the movement of jacks A–B and C–D, so as to insure a uniform speed in the jacks, and at all times keep the jacking girders parallel.

Under normal conditions jacks A–B were operated by one pump, and jacks C–D by a second pump, but a by-pass was provided between the two main lines from the pumps, so that if one pump got into trouble it could be cut out of service by closing the stop-valve. Then by opening the by-pass valve all four jacks would be operated from one pump at one-half speed. This arrangement made it possible to cut out either jack or either pair of jacks, or to operate one pair at a different pressure from the other pair in case of necessity due to unequal wind pressure or unbalanced load. The jacks were operated by water, which was discharged into the supply tanks. The pumps were operated by two men, and the control valve by three men at each corner of the bridge, and could be regulated either by water supply or air pressure. Simultaneous operation was insured by telltales, simultaneously indicating the exact height of all four corners to all the operators.

Mooring Trusses.—In order to secure the suspended span in exact horizontal position while floating on the scows, two vertical mooring trusses were provided to guide it at each end. These trusses, 130 ft. long and 54 ft. wide on centres, were suspended from pin connections attached to the end floor beams of the cantilever arms (see Fig. 6).

They were principally intended to centre the longitudinal axis of the floating suspended span in the same vertical plane as the longitudinal axis of the cantilever arms. They were provided with connections for the mooring lines and tackles and performed no service after the weight of the suspended span had been transferred to the hoisting links. It was intended that their lower ends should then be hoisted up nearly to the bottom chord of the cantilever arms, thus insuring clearance for navigation until it was convenient to remove them, after completing the hoisting of the suspended span.

One pair of trusses was assembled piecemeal by a locomotive crane on the cantilever arm, and the other pair was assembled as units on the cantilever arm floor by the main cantilever traveller and then lowered to position by it. To the lower end of each truss, corresponding with one of the four corners of the bridge, there was attached a 12-part lowering tackle with the lead line carried to an electric hoisting engine installed on the floor of the cantilever arms.

When the span was moved to position between the mooring trusses the first connections to the latter were made by a pair of $\frac{7}{8}$-in. lines about 400 ft. long connected to the opposite corners at the mooring trusses and operated by hoisting engines installed on the floor of the suspended span near the centre point. As the span approached the mooring trusses a second line from each corner was attached to the down-stream corner of the mooring truss, and also operated by the hoisting engines on the suspended span.

As the span neared its approximate position each corner of the span was moored to the opposite diagonal corner of the corresponding guide truss by two $1\frac{1}{2}$-in. steel ropes, eight altogether, each having a working strength of 75,000 lb. These were led over snatch blocks from the bottom to the top of the mooring trusses and there connected to tackles rove with $\frac{3}{4}$-in. wire rope operated by electric hoisting engines on the floors of the cantilever arms.

This arrangement enabled the position of the span to be very accurately adjusted by the operation of the cross-diagonals which, with the normal arrangement of one line at each end, provided security against a seven-mile current and 7 lb. per sq. ft. wind, producing a pressure of 219,000 lb. The trusses and their connections were designed for a maximum transverse force of 300,000 lb. acting through the suspended span. Eventually, conditions of hoisting and mooring were so favourable that comparatively little force was required to be resisted, and the lines served chiefly for initial adjustment.

Transfer Scows.—The bridge was floated from Sillery to the site on six specially designed scows, arranged in groups of three at each end of the span. The scows were designed, first, to meet the requirements of the erection service, and, secondarily, to have as great a salvage value as possible for commercial use after erection was completed.

It was established that the average length and height of waves at the bridge site were respectively about 40 ft. and 4 ft., thus indicating the variations of upward pressure at the four corners of the scow and determining the required strength of bracing. The scows were therefore designed so long and narrow that the reaction produced stresses only in the sway and lateral bracings, which were designed to resist them.

The $32\frac{1}{2}$ ft. by $164\frac{1}{2}$ ft. scows were made with a steel framework and wooden sheathing, and had a draft of about $11\frac{1}{2}$ ft. over the bilge timbers. Each scow was proportioned to carry a load of 970 tons from the suspended span, thus increasing the draft from 1 ft. 6 in. to 8 ft. 2 in. In order to make these scows valuable for other purposes and to provide a considerable salvage after the completion of the work, they were also designed for freighting, with a capacity of 1,500 tons on a length of 123 ft., symmetrically and uniformly distributed with reference to both longitudinal and transverse axis. This load, together with a load of 1,075 tons uniformly distributed over 50 ft. of each end of the scow, or a load of 280 tons uniformly distributed 50 ft. each side of the transverse girders, produced maximum stresses in the truss members.

The unit stresses in the trusses were sufficiently low to permit the entire weight of the suspended span to be carried on four instead of six scows.

Concrete foundations were built on the rock bottom of the river between the falsework bents under the suspended span, and timber sills were carefully lined upon them to give bearing to the scows. These were scuttled on them and remained in position some time before the span was lifted from its falsework bearing.

Arrangement of Scows and Girders.—At each end of the span there was placed a set of three scows rigidly braced close together by four long columns borrowed from the steel falsework, bolted and wedged transversely to the deck, 72 ft. apart on centres. At each end of the span the scows were placed with their transverse axes coincident with the longitudinal axis of the bridge, and with their longitudinal axes in the planes of the floor beams at the second, third and fourth panel points from the end of the span. At each end of the scow a group of four-plate girder track stringers from the suspended span were braced together parallel to the axis of the scow and took bearing on the transverse steel bulkheads. Each set of stringers supported on its top flanges a group of 24-in. 80-lb. I-beams, also borrowed from the suspended span and placed transverse to the stringers and to the floor beams of the span against which they were wedged and shimmed at the subpanel points of the trusses.

Control of Position.—Several 8-in. disc valves were provided in the bottom of each scow and were kept open until the bridge was removed from the falsework. The valves had a total area of one five-thousandth of the area of the bottoms of the scows, and sufficed to let the water rise and fall in the scows as fast as the tide rose and fell. The arrangement prevented the scows from floating until the valves were closed just before the span was moved.

In order to prevent any displacement of the span by the action of the tide or wind after the weight was diminished, and before it was positively decided to move it away in the guide, bents were set adjacent to the sides of the end scows and to the shore ends of all the scows.

Reinforcing Trusses.—As some modifications of the normal truss stresses were developed by supporting the trusses on six floor beams, instead of on the end lower chord pins as in service, temporary provision was made to care for tension in the top chord joints U-2 and U-16, and the bottom chord eyebars L0–L4 and L14–L18 were stiffened with longitudinal timbers and transverse lagging, bolted on to give them compressive strength. Some of the web members in the trusses directly over the scows were also specially designed and stiffened to resist stresses at this time.

Handling Loaded Scows.—A set of tackles was attached to the north-west corner of the west group of scows and to the south tower and operated by a hoisting engine seated on the west end of the span. Another set of tackles, attached to the east group of scows and operated by an engine at the east end of the span, was used to pull the scows perpendicularly away from the shore and from the falsework when it was swung through a horizontal angle of 90 deg. and moved to the centre of the river around a crib, to which was anchored a 1,200-ft. steel cable attached to the north-east corner of the east group of scows.

When the span thus arrived at right angles to the current a large tug was made fast to the towing shackle lashed to the centre vertical post of the down-stream truss. Two smaller tugs were attached to the ends of the span on the down-stream side and other tugs were attached to the ends of the span on the up-stream side. The up-stream tugs kept the span at right angles to the current and in the centre of the channel, and the down-stream tugs backwatered most of the time until the span was about 400 ft. down-stream from the bridge site at the period of high tide slack water. It was then attached to the mooring trusses by preliminary $\frac{7}{8}$-in. lines, as already described, and the centre of the span was approximately lined up with balloons attached to lines connecting the ends of both cantilever trusses across the channel. The five down-stream tugs then began to pull away from the bridge site and eased the span to position quickly and accurately.

(To be continued.)

NOTE.

Gas-Engine Vibrations.

The electricity works of La Chaux-de-Fonds, Switzerland, installed in 1899 in their power station two gas engines of the Gasmoterenfabrik Deutz, each developing 250 h.p. at 180 r.p.m. They are four-cycle engines with two parallel cylinders and cranks at 360 deg., each motor directly driving a dynamo. Each of the two units had to be erected on a block of concrete, 7 m. by 9.5 m. and 6 m. high, as the soil consists of loam and marl to a depth of 20 m. Soon after the installation the houses in the neighbourhood, especially those built on the same marl, were disturbed by vibrations, described as unpleasant though not dangerous. The Deutz firm fixed balance weights to the crank arms and to the flywheels. The result was that the wave length of the vibrations was altered, and that other houses were shaken. In order to reduce the trouble, the motor speed was lowered to 165 revolutions. That involved a sacrifice of power, of course, but as the motors were rarely wanted, nothing further was done until loss of water from the tank of a gas holder near by suggested that a crack had developed in that tank. The crack had probably been formed when a deep excavation was made near the tank; but it had apparently been widened by the vibrations, for the running of the motors certainly increased the rate of water loss. The motors were therefore stopped, and Dr. Stodola was consulted as expert. Dr. Stodola considered the balance weights to have been correctly estimated and placed so as to balance the horizontal reciprocating forces; but there were also centrifugal forces at right angles

to the former and not acting at the centre of gravity, and these forces tended to make the machines oscillate in pendulum fashion together with their foundations on the elastic cushion of soil. To avoid the oscillations Stodola suggested that the balance weights should simply move in the horizontal plane, so that the centre of gravity of the system should remain in the same plane during the running of the engines. His suggestion could be carried out in two ways: either a balance weight might be added to each unit so as to quiet that unit, or the one unit might be balanced by the synchronous movements of the other unit. The adoption of the second method would have necessitated arrangements for ensuring a precise concordance of the two units and, further, an absolute rigidity of the foundations, which might have been secured by providing a heavy cast-iron frame round the two blocks of concrete. This solution was not tried, therefore. The first method looked simple and was adopted. From the end of the shaft of each motor a balance weight is so moved on horizontal guides by an auxiliary crank that this weight arrives at its dead point at the same moment as the piston. The resultant of forces of the two weights had to coincide with the resultant of the forces of the piston, *i.e.*, it had to be placed in the central plane. A balance weight placed in the middle between the two motors would have been simpler still; but that modification would have called for a replacement of the shafts and flywheels. The first-mentioned arrangement was hence decided upon and carried out by the Lokomotivfabrik Winterthur. So far, we see from the *Schweizerische Bauzeitung* of September 23, this has been done only in the case of the one motor. But as the vibrations have been reduced to a minimum, although the motor is once more run at the original speed of 180 revolutions, the solution of the problem is considered to have been successful.

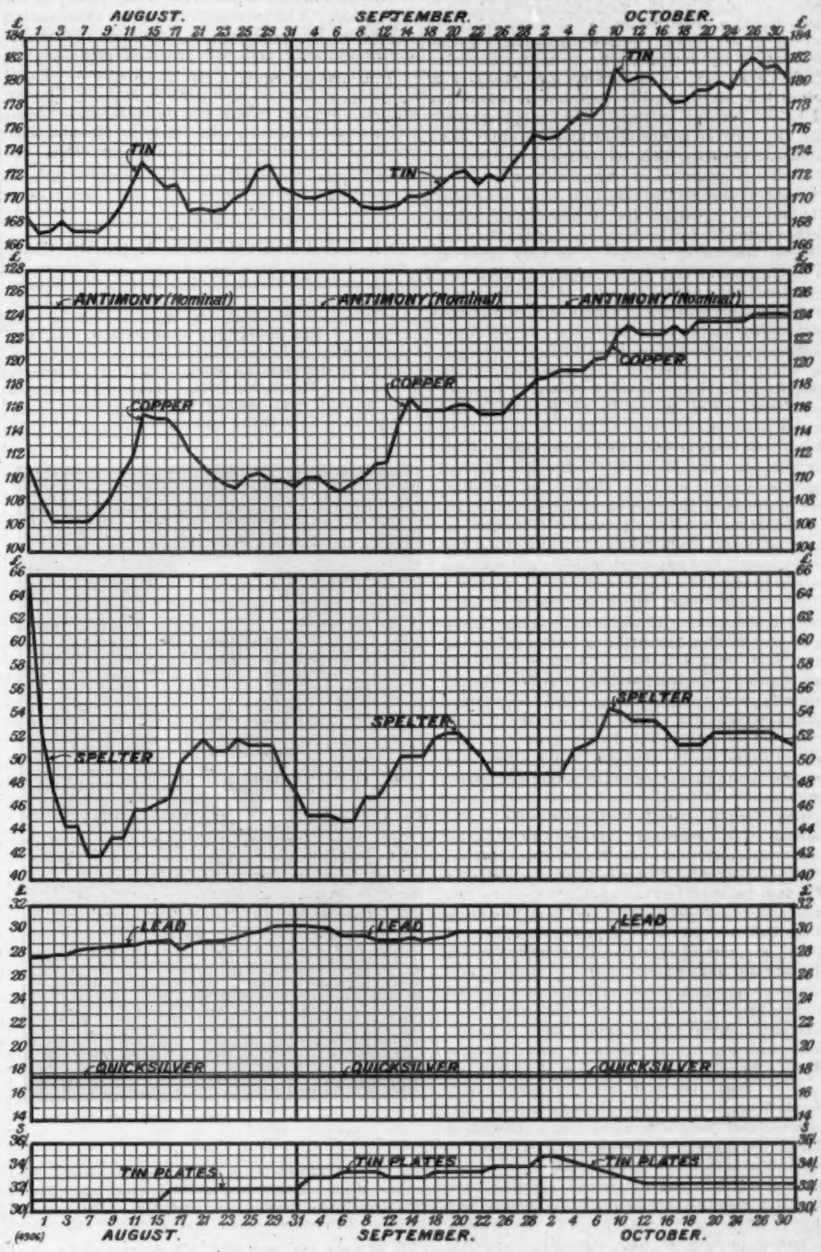
Russian Trade Prospects.—Under the title of "British Opportunities in Russia," a small pamphlet, by Mr. L. A. Rojansky, giving data as to the methods by which Germany secured so large a share of Russian trade in the past, has been published (price 2*d.*) by the Anglo-Russian Translations Bureau, Limited, 133–7, Finsbury Pavement, E.C.

A 60,000-k.v.a. Generator.—According to the *Electrical World*, New York, the Siemens-Schuckert-Werke, of Berlin, are building a 60,000-k.v.a. generator wound to 6,600 volts and running at 1,000 r.p.m. The current generated will be stepped up to 110,000 volts for transmission purposes. The main difficulty to be overcome in constructing such enormous machines is the question of transport as the railway loading gauge limits the dimensions.

The Fuel Value of Coal-Tar Pitch.—The total yearly production of pitch at the 248 tar works registered in 1915 has been estimated at over 1,000,000 tons. With the sudden closing of the Continental market in August, 1914, and the continued restrictions on export trade, hitherto the chief method of disposal, the outlook for pitch and, incidentally, coal-tar, in the near future is extremely problematical. Its calorific value, viz., 15,000 to 15,500 British thermal units per lb., is higher than that of the best quality Welsh steam coal, while its present price in the Midlands and London district respectively is only about one-third to one-half that of such coal; moreover, it is practically pure carbon, and ash and moisture free, so that in whatever proportion it may be added to other staple fuels, more than an equivalent amount of such fuel may be released for sale or export. The relatively high price realised for pitch has in the past naturally precluded its direct use as fuel. The chief difficulty experienced in attempting to burn pitch has been the low fusing and volatilising temperature common to all pitches and the consequent tendency to separate carbon in the form of dense smoke. Compared with average bituminous coal containing 28 per cent. volatile matter, pitch contains about 55 per cent., the remainder being practically pure amorphous carbon. The claim is made that by means of a special fire-bar coal-tar pitch may be consumed in conjunction with coke with considerably less than the ordinary amount of smoke observed at the chimney of a coal-fired boiler. The *modus operandi*, which has been tried with some success in certain gas works boilers, is to substitute a number of "pitch" bars for an equivalent number of existing fire-bars in a boiler furnace fitted with steam-jet forced-draught apparatus of ordinary construction. Pitch, broken to any convenient size, is fed on to the pitch bars, where the heat of the surrounding fire causes it to collect and volatilise, the rate of such volatilisation being controllable within limits which ensure practically smokeless combustion. The partially coked residue remaining after the more volatile constituents have been burnt off is periodically raked on to the rear portion of the grate, where its combustion is completed.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



Note.—In the diagrams above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for antimony and lead are for English metal in both cases, whilst those for spelter are for American metal. The prices are per ton, but in the case of quicksilver, however, the price is per bottle, the contents of which weigh about 80 lb.; the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7 the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45 *ante*.)

Scandinavian Shipping.—The Swedish-North America Line has decided to increase its capital from 445,000*l.* to 1,341 000*l.* for the purpose of increasing the company's tonnage by building new vessels or by purchase, when found expedient. At the same time new shipping concerns are being formed almost daily in one or the other of the Scandinavian countries, often on a somewhat slender foundation, but as a rule the capital is being vastly over-subscribed. A number of old shipping companies are increasing their capital, and an odd company or two prefer to liquidate, disposing of their tonnage at fancy prices.

New Zealand Ironsand.—Pig of excellent quality is reported to have been recently produced in New Zealand from deposits of ironsand at Taranaki, New Plymouth, New Zealand. Pig-iron was produced from this Taranaki ironsand so long since as 1848, but little has been done at present in turning the sand to commercial account. The cost of producing the pig recently made was 2*l.* 18*s.* 10*d.* per ton; but it is considered that this could be reduced by the introduction of up-to-date appliances. Coal is also found in the Taranaki district. The imports of pig-iron into New Zealand in 1914 were 10,805 tons, of the estimated value of 225,567*l.*

LITERATURE.

Text-Book of Theoretical Naval Architecture. By E. L. Attwood, M.I.N.A., R.C.N.C. London: Longmans, Green and Co. [Price 9s. net.]

Text-books on Naval Architecture, covering the whole field of theoretical work, are both numerous and excellent, and the literature on the subject is constantly being enriched by papers read before the Institution of Naval Architects and kindred institutions. But to the majority of ship draughtsmen, as well as to the less advanced students, the average text-book and paper are of comparatively little use—the former because the very fullness of treatment of the subject is rather apt to obscure the parts directly applicable to the daily work of the drawing office, and the latter because it is very often of such an academic and highly technical character as to appeal only to the expert. It is in his selection and treatment of the essential calculations and investigations made every day in the modern drawing office, as distinct from the academic investigations which are seldom or never carried out in practical shipbuilding, that Mr. Attwood achieves a great measure of success in his text-book, for, with the possible exception of that on the rolling of ships, each chapter deals with calculations which are in constant use and with which every efficient draughtsman and student should be familiar. Direct evidence of the success which has attended the publication of Mr. Attwood's text-book of Theoretical Naval Architecture is furnished by the fact that since it first appeared in 1899 eight editions have been printed.

Within recent years there has been a large increase in the number of technical evening classes held in the various shipbuilding and engineering centres and affiliated to a central technical college, so that there has naturally arisen a demand for suitable text-books dealing with the various subjects taught. For such a purpose the "Text-Book of Theoretical Naval Architecture" is pre-eminently suited, as it combines the maximum of utility with what is, in the case of young apprentice students, an almost equally vital consideration, viz., cheapness, the published price being 9s. net.

Starting with elementary calculations of area, volume, weight, moment, &c., the practical application of the Trapezoidal, Simpson's and Tchebycheff's rules is soon reached, and the application of the two latter sets of rules—both singly and in combination—to the calculations of displacement, centres of buoyancy, &c., embodied on the displacement sheet, explained fully and clearly in the letterpress and by means of specimen displacement sheets as used by leading firms of shipbuilders. The use of the planimeter and integrator for finding areas, volumes, moments and moments of inertia is also fully and clearly explained, and the methods of combining the results thus obtained with Simpson's and Tchebycheff's rules in various calculations indicated. Transverse and longitudinal stability, alteration of trim due to adding or moving weights, effect of bilging and of free water in holds, &c., methods of calculating statical and dynamical stability, are investigated, also the heel produced by gunfire and turning. Calculations of weight and of the position of centre of gravity of hull, strength of davits, derricks, shaft bracket arms and rudder stocks, also the hogging and sagging stresses experienced by a ship balanced on the crest and across the hollow of a wave respectively, are explained. The variation in hogging and sagging stresses which occur when the vessel is inclined from the upright position, also the effect of the "Smith" correction for buoyancy which is necessary, due to the orbital motion of the particles in the wave structure, are explained. The chapters on Horse-power and the Rolling of Ships are very complete and contain all the information ordinarily necessary on these subjects.

The new chapter on the Turning of Ships contains much useful information on the subject of rudder shapes and areas in way of rudders and propellers, and the influence of the thrust from the propellers on the efficiency of rudders. A short chapter on the usual launching calculations, along with the foregoing, completes the new work in the present edition. By no means the least useful portion of the book is the appendix, containing as it does proofs of Simpson's and Tchebycheff's rules, an investigation of the alteration of the stability of a ship due to docking or grounding, and an explanation of the theory of the integrator. A large selection of the examination papers set by the Board of Education is included in the appendix and will prove of great use to students preparing for these examinations. To all students of naval architecture and to all ship draughtsmen and others who desire to make themselves acquainted with scientific principles and their practical application in the drawing office, the "Text-Book of Theoretical Naval Architecture" is to be highly recommended.

THE LATE DR. CHARLES A. HARRISON.

Last Saturday there passed away at Hexham, at the age of 68, Mr Charles A. Harrison, for many years engineer-in-chief to the North-Eastern Railway Company (Northern Division). Mr. Harrison retired from his position with the railway company last year, and has since been their consulting engineer. In his former position he followed his uncle, Mr. T. E. Harrison, who died on March 20, 1888. The duties, however, were divided, and instead of one engineer being responsible for the entire system, the company's lines

[*Elliott and Fry, Photographers.*

were divided into northern and southern divisions, the subject of our memoir taking the former, which then extended from Berwick to Ferryhill, and west to Consett. In recent years the division has been extended.

Mr. Charles Harrison was the son of Colonel Harrison, R.A., and was born in India, at Vizianagram, on March 27, 1848. He went to school at Marlborough College, but did not enter the army. Instead, he went into the office of his uncle, and was employed on much work on the railway. For a time he was engaged in constructive work on many branch lines, and in 1872 he became resident engineer at the Hartlepool Docks Extension. This position he held for 10 years, during which time he was also engaged on the diversion outside the dock area of the loop line between East and West Hartlepool. This was opened in 1877.

After the subject of our memoir succeeded to his uncle he found very much to occupy him. There was the doubling of the line between Gateshead and Pelaw, the doubling of the line between Newcastle Central Station and Heaton, including the arch bridge across Dean-street, the coal staiths at Blyth and Dunston, the Seaham and Hartlepool line, the line from Birtley to Annfield Plain, and the works at New Bridge-street. This list represents a great aggregate of work, much of it presenting very considerable difficulty in execution, but not generally imposing in appearance. The monumental structures which Mr. Harrison designed were mainly bridges. These were the large viaducts on the Seaham and Hartlepool line, the Queen Alexandra Bridge across the Wear at Sunderland, and the King Edward Bridge at Newcastle. This latter is a very important work, and forms a lasting memorial to its designer. For nearly 60 years the whole of the North-Eastern Railway traffic between north and south passed over three lines of railway upon the old high-level bridge, but in 1899 the directors obtained powers to construct an entirely new bridge with four lines of railway. The bridge is carried on three piers, one at each margin of the river, and one at the centre. These were built upon caissons carried to a height of about 5 ft. above high water. The two main spans are of 300 ft. each, with a land span on the north side of 231 ft. and on the south side of 195 ft. The clear headway to the girders above high water is 83 ft. 6 in. The piers are of granite; they have curved cutwaters at each end, and are lightened by voids. There are five girders to each span, of lattice design, 27 ft. high, and they are placed 11 ft. apart between centres. The track is carried on longitudinal timbers resting on floor plates supported by cross-girders attached to the top boom of each main girder. The formal opening by His Majesty King Edward VII took place on July 10, 1906, and passenger traffic was commenced on October 1 of the same year.

Mr. Harrison joined the Institution of Civil Engineers as a member in 1877, and later he became a member of council for a time. He received the degree of D.Sc at Newcastle in 1906, as a tribute of honour to his work in connection with the King Edward Bridge. In private life he was an active churchman, and he also took some part in civic duties. He leaves four sons and two daughters.

Smart Work in Factory Construction.—Some details are furnished regarding one of the national projectile factories, which show the smart work achieved in construction and equipment. The details given refer to a factory with 11 acres under one roof, in addition to accessory buildings; but similarly satisfactory records could be made regarding others. The proposal for the factory was made on July 8, 1915, and sanctioned on August 17. The land on which the factory now stands was then chiefly a dumping ground. Part of it being subject to inundations, part of the construction had to be founded on piles. The ironwork was started on September 25. By March 26, 1916, the power was installed, and much of the machinery had been manufactured in Britain. In the first week of June 127 shells were made. Within a year of the *sanctioning* of the proposal 48,549 shells had been delivered. The output is now over 10,000 a week—and they are big shells. How was it done? asks Mr. James Douglas in a special article. It was done in principle by putting a big armament firm in charge, but this firm supplied only two men direct, though it gave foremen a fortnight's course of training in its own shops. The manager was brought from India. There was no difficulty about female labour; but the skilled male labour had to be invented, created, conjured up out of nothing, for when this national projectile factory was first thought of, the country was supposed to have been swept clear of that commodity, and it practically was. The national projectile factory stands there to-day an achievement as magical and incredible and overwhelming as any palace of Aladdin.

The Large German-Luxemburg Mining Company.—An interesting light has been thrown upon the doings of this concern, one of the largest in Germany, by the action taken by a large section of thoroughly dissatisfied shareholders, who strongly disapprove of the autocratic way in which the chairman, Herr Hugo Stinnes, conducts the business of the company. The object of the move is to limit and reduce the power of the board. The company has, says a circular just issued, during the last four years applied about 72,000,000 marks to writings-off, more than half the share capital, and this has been done at the cost of the shareholders, who for two years received no dividends; for last year a dividend of 7 per cent. has been paid. The very magnitude of these writings-off explains the unfavourable position in which the board had brought the company by their policy of boundless expansion. That the company has now been able to consolidate itself is the outcome of the war and cannot be put to the credit of the board. Quite recently they had purchased further shares to the extent of 10,000,000 marks in the Saar and Mosel Mining Company, at the very high rate of exchange of 182 per cent.; the German-Luxemburg Company already holding a similar amount of shares in that company, which barely earned enough for writings-off. These 20,000,000 marks of shares had been purchased by the board without the opinion of a general meeting being asked. According to the statutes of the German-Luxemburg Company, neither the general meeting—that is, the shareholders—nor, for the matter of that, the board, exercise any influence upon the management of the company, the whole power being literally vested in Herr Hugo Stinnes. Under the usual pretext that it would not be to the advantage of the company, any explanation has been withheld at the general meeting, both about this and almost all matters of interest, but the shareholders in question evidently mean to have the question duly sifted, especially as regards the recent purchase of the above-mentioned 10,000,000 marks' worth of shares.

THE DEVELOPMENT OF APPLIANCES FOR HANDLING RAW MATERIALS AND MERCHANDISE AT PORTS AND OTHER LARGE CENTRES OF TRAFFIC.*

By Sir John Purser Griffith, M.A.I., M.Inst.C.E.

(*Concluded from page* 421.)

Oil-Handling Plant.

The story of progress in the handling and transport of petroleum reads like a romance. The important part it and its by-products play in our everyday life has been brought into prominence by the restrictions in its use forced upon the nation by the world-wide war now in progress. We have learned how dependent we are on its supply.

Amongst the first important discoveries of petroleum we may refer especially to those in Pennsylvania, where William Drake "struck oil" in 1859, less than 60 years ago. In those early days of the industry the oil wells and the refineries were close together. This was principally due to the heavy cost of carriage to the markets, the refined oil being at that time the principal marketable product.

The oil was transported in wooden barrels, carried in barges on the waterways, or in horse wagons by road, and at a later date by rail. As the industry extended, and shipments to Europe increased, the discovery was made that transport through pipes to large refineries near the coast was feasible and economical. The battle of vested interests was fiercely fought over this revolutionary change, but the pipe-line won the day over the transport wagon.

Thousands of miles of trunk pipes ranging from 4 in. to 8 in. in diameter exist for the transport of petroleum from the wells to the refineries, while tens of thousands of miles of smaller feeder pipes have been laid to collect the oil from its various sources and lead it to the delivery or trunk mains.

The introduction of large and scientifically equipped refineries was followed by the discovery of the value of the distillations and by-products of the crude oil. The crude oil was separated into three principal groups: inflammable oils, burning oils, and lubricating oils. With advances in the refining process, the cost of production greatly decreased, and the export trade to Europe advanced by leaps and bounds.

Although the transport of oil through pipes on land had made such progress, yet its transport across the Atlantic continued in barrels for many years. This old system of sending oil in barrels in sailing vessels was in full swing in the eighties, and in the port of Dublin until 1899, when the Anglo-American Oil Company opened their tank storage depot. The first tank steamer entered the port of Dublin in February of that year. The effect was startling. Instead of a sailing vessel with from 1,000 to 2,000 tons of oil in barrels occupying the harbour quays for weeks, the tank steamer with from 5,000 to 10,000 tons of oil was discharged, and the oil pumped ashore and stored in the depot tanks, within from 24 to 48 hours from the arrival of the tank steamer. Thus, to the great advantage of the port, through shorter occupation of its valuable berthage and freedom of the quays from the obstruction caused by barrels, this application of modern methods of handling petroleum has reduced the cost of oil to the consumer, cheapened freights, and added to the available usefulness of the harbour space.

The shortage of tonnage of tank steamers caused by the war has this year forced the Anglo-American Oil Company to import a certain amount of oil in barrels by sailing ships, and we have been forcibly reminded in Dublin of what this means. The Norwegian sailing ship Nordfarer brought 18,500 barrels of petroleum in August of this year, approximately equal to 3,000 tons of oil. This vessel, even with the aid of electric cranes, took 10 working days to discharge, whereas if that amount of oil had been imported by tank steamer, it would have been discharged in 1 day—a saving to the port of nine working days.

Timber Handling.

The handling of timber, both at the loading and discharging ports, still involves much manual labour. Until quite a recent date balk timber was brought in rafts for shipment, and hauled into the holds of sailing vessels through port-holes formed in the ship's bows. On arriving at their destination the balks were discharged into the water through the same port-holes, and formed into rafts either for storage or transit. The timber was hauled into or out of the ship's port-holes by winches and tackle.

With the advent of the steamship into this trade the balk timber is generally loaded and discharged through the deck hatches by the ship's steam-winches and derricks. In the port of Dublin the timber is now frequently discharged by the portal electric cranes on the quays, with satisfactory results as regards time, and great facilities for stacking and handling the timber on the quays. Planks, deals and boards were formerly exclusively discharged by manual labour, but have of late been discharged, landed and stacked by the electric cranes. Conveyors have been introduced in some places where the timber storage ground is within reasonable distance from the quay, and elevators of a special form have also been adopted in a few places for stacking planks.

Appliances for Handling Heavy Machinery, &c., in Ports.

In a large port it is essential to have appliances to deal with heavy lifts, such as railway rolling-stock, engines, boilers and machinery of all kinds. The example to which I would draw your attention is the 100-ton electric crane in the port of Dublin. Before its erection, in the year 1905, it was no uncommon occurrence for heavy loads to be sent round to Belfast instead of being landed in Dublin. The crane is of the hammer type, all the weight of the crane and load being carried by the crane post to a bearing on the ground-level, the overturning moment being taken up by a four-leg trestle frame, with horizontal rollers and roller path at the top of the frame. The crane is capable of lifting loads up to 100 tons at a radius of 75 ft. An auxiliary lift is provided for loads under 20 tons, working to a maximum radius of 80 ft. The test load of the crane was 150 tons. Loads between 50 and 100 tons can be raised at the rate of 5 ft. per minute, and below 50 tons at the rate of 10 ft. per minute, with the main hoist. Loads below 20 tons can be raised at the rate of 20 ft. per minute by the auxiliary hoist, and the crane can make a complete revolution with any weight in eight minutes. The contractors for the steel work were the United Machine Manufacturers, of Augsburg and Nuremberg; Messrs. Siemens Brothers were sub-contractors for the electrical equipment; and all foundation work and masonry were carried out by the engineer's department of the port. The methods adopted for the erection of the crane, including the steel staging, were striking exhibitions of the best German practice, and for efficiency and thoroughness were full of interest to the engineer and worthy of imitation.

Appliances for Handling General Merchandise.

From amongst the numberless appliances for handling general merchandise I have selected some examples of elevator-conveyors and runways which are in use in several of our British ports for dealing with frozen meat, cheese and tea.

I am indebted to Messrs. Rownson, Drew and Clydesdale, of Upper Thames-street, for interesting information concerning this plant, which is at work in the port of London. Donald's patent elevator-conveyor is taken to a ship, erected on the ship, and removes frozen meat from the steamer to carts and railway wagons standing on the quay alongside or near by. There are similar elevator-conveyors dealing with cheese and tea.

Reference has been chiefly made to appliances for loading and unloading vessels; but, in addition to these, there is the necessity of being able to handle the cargo when it is on land either before loading or after discharge. Unless the quays and sheds are cleared rapidly, it is obvious that the discharge and loading of vessels will be delayed for want of quay space to deposit and sort the goods.

If a port is not sufficiently provided with well-designed sheds and ample quay space for the reception of cargoes and appliances for handling and sorting merchandise of all descriptions, loss and extra expense will be incurred. Facilities for the rapid removal of goods from the port are also of the greatest importance, while easy connections with the railways and the inland navigations of the country are essential in the interests of the internal trade of the country.

In this respect some of our older ports controlled by port trusts labour under great disadvantages when competing with more modern ports, and specially with those controlled by railway companies. The defective railway connections of the older ports often necessitate costly cartage between the ships and the railways.

The railway-owned port has the advantage of a co-ordinated control of its railway and shipping traffic arrangements. A similar remark applies to traffic arrangements where railway companies own fleets of steamers trading to a port, and are able to connect their railway system with the berths occupied by these steamers. In this connection I should wish specially to refer to the arrangements of the Lancashire and Yorkshire Railway Company at the port of Goole. Through the kindness of Mr. J. A. F. Aspinall, the general manager, his goods traffic manager, Mr. Marriott, and the chief engineer, Mr. Rattray, I was able to visit the port of Goole and inspect the arrangements for handling the company's Continental traffic at that port. A single-story shed, with large floor area, has been erected at the steamboat berths, into which the railway wagons run. There is ample floor area for depositing goods, and this is commanded by overhead cranes which traverse the shed from the quay to the rails. An ingenious combination of jib cranes and overhead cranes allows of the cargo being taken out of the ships' holds and landed either in the sheds for sorting purposes or into railway wagons standing at some considerable distance away.

One of the best examples of handling goods traffic of a general character which I have seen is at the Lancashire and Yorkshire Railway, Oldham Road Goods Station, Manchester, where a very complete system of overhead electric cranes deals with all classes of traffic, and electric motor-trucks are used on the platforms to supplement the cranes for taking goods from one portion of the shed to another. The arrangements for handling, sorting and delivering the goods are about the most perfect which I have met with, and are worthy of study by those interested in this most important economic problem.

The handling of wool and cotton in the manufacturing areas of Yorkshire and Lancashire has taxed the ingenuity of railway engineers and managers. The enormous volume and bulkiness of the packs of wool and bales of cotton arriving at such centres as Bradford, Manchester and Oldham make the handling and storing of these materials a gigantic problem. The principle now generally accepted as the best is to pile the bales to a great height, irrespective of their marks, in sheds commanded by overhead cranes. Some of the finest examples of this kind of storage are to be found at Werneth, where the Lancashire and Yorkshire Railway have a large shed for the storage of cotton, and at the cotton safes of Trafford Park, which have been evolved by the ingenuity and enterprise of Mr. Marshall Stevens, the chairman of the Trafford Park Estate, Ltd. This system has also been adopted at New Orleans, whence so much cotton is shipped.

The same principle is adopted in the more modern wool warehouses at Bradford belonging to the Lancashire and Yorkshire Railway.

The Influence on Labour of Appliances for Handling Raw Materials and Merchandise.

There is an aspect of the problem under discussion which appears to me of supreme importance and interest—namely, the effect on labour of appliances for handling raw materials and merchandise in our ports. "Labour-saving appliances" is a familiar expression. Is it a strictly accurate term?

The working man understands it as meaning arrangements for doing without him. His views with suspicion all machinery which tends to expedite output. His idea is that its introduction means so many men displaced, and so many men thrown out of work, the earning-power reduced, and increased poverty the result. Have these fears been justified by past experience? I think not. Instead of speaking of "labour-saving appliances," can we not gradually substitute the term "labour-aiding appliances"?

Allow me to quote a sentence of Mr. Harold Cox in his lecture to us on "Industrial Improvement" last March, with which I am in complete sympathy. His words were:—

"Unfortunately, we still find that workmen in many places look upon improvements in machinery with very much the same suspicion as in the beginning of the nineteenth century, when they used to break the power-looms. It is very curious, for when you come to think of it, the first instinct of man, however unsivilised he may be, is to make a tool to help in his work. Indeed, man might almost be defined as a tool-using animal. I venture to lay down this proposition that, so far as material comfort is concerned, the progress of mankind is dependent upon the progress of machinery."

Casual Labour and Under-Employment in Ports.

Those of us who are acquainted with the working of large ports are familiar with the meaning of casual labour and under-employment as associated with the handling of cargoes entering and leaving our ports. There is, of course, under-employment in almost every trade, represented by a fringe of hangers-on, who are employed temporarily to meet emergencies. But in no branch of trade has it assumed such large proportions as in the shipping industries. The fluctuations in discharging and loading of ships in our ports are due to various causes, such as tides, weather and trade conditions. The docker may earn large wages when work is brisk, and a certain proportion of the dock labourers may have constant employment; but still a very large percentage of the dock labourers come under the class of casual labour, and within that class there are distinct divisions or grades corresponding to varying grades of poverty. Even amongst casual labour earnings are often large, but this is followed almost invariably by periods in which the man does not earn what can, by the utmost stretch of imagination, be called a living wage.

Have you ever witnessed the scenes associated with the engagement of the casual dock labourer? Early in the morning men may be seen making their way to the docks. Most are badly clothed, and many obviously ill-fed. On arrival at the docks they collect in groups at the recognised centres of engagement, or "stands," as they are called. On the appearance of the foreman, whose duty it is to engage men for his employer, they line up, and the foreman selects his men. The selection is first made from old acquaintances, whose powers are known, or for whom he has some special leaning—sometimes for good reasons, sometimes for bad. It has been said that "round each foreman there is a body of men whose chance of employment, like the atmosphere round the earth, grows thinner and thinner, until it diminishes to the vanishing-point at which a man cannot subsist at all. There will be a nucleus of men in practically permanent employment; others further down the foreman's list who will average three or four days a week; and there will be some who will only pick up a scrap of work now and again. This is the daily agony or fate of a man who, from age or some other cause, has lost firm hold of employment."

The sad story of the docker's life is told in Reports of Royal Commissions, books, pamphlets, and magazine articles devoted to the subject. To those interested in it, I would commend a little book, published during the current year, entitled, "Casual Labour at the Docks," by Mr. H. A. Mess, B.A. It describes the methods of engagement of the dockers; discusses the consequence of irregular earnings; tells how dock labourers are recruited; refers to past attempts at reform, and makes suggestions for the future. The writer says: "The problem of dock labour is that of chronic over-supply of labour offering itself in response to demands which are irregular as to time and fluctuate in volume."

No suggestion is made in this little book that advantage should be taken of modern machinery and appliances to amend this state of affairs: and yet this is, I believe, a direction in which we should look for relief.

These labour problems have occupied the attention of many thoughtful minds. Much has been attempted to mitigate the lot of the casual docker, with a certain amount of success where employers and workmen have co-operated. This combination is, unfortunately, too rare, and mutual suspicion has barred progress. May we not hope and work for the day when employers will

* The "James Forrest" Lecture, delivered before the Institution of Civil Engineers on October 24.

see that liberality towards their workmen will pay better than the old method of trying to get the largest amount of work for the smallest possible wage, and when workmen will see and acknowledge that low output will necessarily result in low wages?

Mr. Winslow Taylor, an American engineer, in his book, "The Principles of Scientific Management," writes as follows:—

"The great majority of workmen still believe that if they were to work at their best speed they would be doing a great injustice to the whole trade by throwing a lot of men out of work, and yet the history of the development of each trade shows that each improvement, whether it be the invention of a new machine or the introduction of a better method, which results in increasing the productive capacity of the men in the trade and cheapening the costs, instead of throwing men out of work, makes in the end work for more men.

"The workmen of almost every trade have before them an object-lesson of this kind, and yet, because they are ignorant of the history of their own trade even, they still firmly believe, as their fathers did before them, that it is against their best interests for each man to turn out each day as much work as possible.

"Under this fallacious idea a large proportion of the workmen of both countries (America and England) each day deliberately work slowly, so as to curtail the output. Almost every labour union has made, or is contemplating making, rules which have for their object curtailing the output of their members; and those men who have the greatest influence with the working people, the labour leaders, as well as many people with philanthropic feelings who are helping them, are daily spreading this fallacy, and at the same time telling them that they are overworked.

"As engineers and managers, we are more intimately acquainted with these facts than any other class in the community, and are, therefore, best fitted to lead in a movement to combat this fallacious idea, by educating not only the workmen, but the whole of the country, as to the true facts."

The solution generally accepted by those who have devoted attention to this difficult problem is to form a staff of permanent labourers in each port and reduce the casual element gradually. I can only refer you to what has been done in the port of Liverpool and by the London port authority in this direction. It is only a beginning, but seems to show that the proposition is not impossible or Utopian. Where it has so far failed it has been due to lack of co-operation amongst the employers, and to the ingrained suspicion of the men with regard to any proposal for the abolition of casual labour.

Many employers view with disfavour any proposal to abolish the large reservoir of under-employed labour, which at present is allowed to accumulate in order to meet their widely-fluctuating demands. The dockers also look with suspicion on proposals to reduce casual labour. They think that permanent employment means smaller wages and reduction of the number of men employed. There is a certain *esprit de corps* which makes men shrink from doing anything which they imagine will throw other men out of work, even if it might possibly be to their own advantage.

The permanent staff of workmen should be well paid, and work for a reasonable number of hours. They might be divided into shifts, if found desirable. Such a well-paid permanent staff would be well nourished, and capable of a reasonable amount of overtime in cases of emergency. Now, with such an effective staff, supplemented and equipped with appliances for handling raw material and merchandise, we have a most elastic and efficient combination. By this means we shall move towards Mr. Harold Cox's ideal:—

"And by a more extended use of machinery and a more scientific use of human muscles we can secure on the one hand a greater output of work with a diminished cost of production; and on the other, higher wages for the worker with less physical exertion. Those are the ideals for the industrial development of the future. At present their realisation is obstructed by class suspicion resulting in class warfare."

It has been estimated that on the average about 30,000 men daily seek for work at the docks and wharves of the port of London, and that about 20,000 men obtain it. In other words, 10,000 men on an average seek for work and do not find it. We may safely conclude that similar conditions are met with in other large ports. It is the fluctuating demand for dock labour that has led to the high rates of wages demanded by the men, and to the bitter strikes with which some of us are familiar. It is the high rate paid to the casual labourer which lures men to the docks and is constantly filling up the ranks of the under-employed. They overlook the fact that the high hour-rate is only paid for the actual time worked, and they do not take into account the hours of waiting and of unemployment for which no payment is received. Casual labour has been described as a subtle form of sweating.

Engineers know that, even when idle, machinery requires watchful care, yet when the complex human machine is out of work it is often allowed to remain neglected and uncared for. It will probably be said that our poor-law relief is intended to meet such difficulties; that the Education (Provision of Meals) Act, 1906, was specially passed to guard the children from the evil effects of their parents' under-employment. Is it not our experience that these costly methods of relief scarcely touch the problems of poverty to which we have referred?

You may naturally ask, What has led me to introduce such social problems in "The James Forrest Lecture"? My answer is, "Nothing but a sense of the gravity of the issues involved."

We have by the continuance of casual labour in our docks maintained an army of under-employed, under-clothed, under-fed and badly housed men, with their dependent families. We have, thereby, fomented discontent, and trained up a population demoralised by poverty, poor-law relief, and so-called charity, and constituting, in my opinion, a national danger.

During the last few years we have in Dublin been face to face with labour trouble. Larkinism has been a familiar phrase. The employers and employed have been in a chronic state of war. The Citizen Army, organised as an armed force from the membership of the Irish Transport Union, has been a standing menace, and the Government looked on with apathy and indifference. When the Irish rebellion of 1916 broke out in Dublin on Easter Monday, James Connolly, the leader of the Irish Transport Union and the successor of James Larkin, supported by the Citizen Army, was the driving force of the outbreak. I have no doubt in my mind that causes which lead men to combine in the manner in which the members of the Irish Transport Union combined are a danger to the State. Those causes in Dublin were the casual labour of our dockers, with its accompanying poverty and miserable housing.

My desire is that we as engineers may be able to assist in finding a solution of this pressing problem of casual labour. The development of appliances for handling raw materials and merchandise must, I believe, prove a potent factor to this end, bringing increased permanent work, increased pay, shorter hours and better homes to the labourers in our ports. My experience shows that the position of an engineer frequently affords opportunities for influencing both employers and employed, and of mitigating the suspicion so frequently existing between them. For this reason there would appear to be reasonable hope that our influence may be helpful in promoting the use of appliances for handling raw materials and merchandise. If this end is attained, we shall, I believe, further the objects for which this Institution was founded, as defined in our charter, by directing the great sources of power in nature for the use and convenience of man.

I wish to thank the following gentlemen and firms, to whom I am greatly indebted, for the kind assistance they have given me in the preparation of this lecture:—Dr. William H. Maw, for his advice and suggestions as to dealing with the subject. Mr. J. A. F. Aspinall, for facilities given me to inspect the methods of dealing with goods traffic at Manchester, Oldham, Bradford, Goole and Fleetwood on the Lancashire and Yorkshire Railway. Mr. W. H. Bartholomew, of the Aire and Calder Navigation. Mr. Marshall Stevens, chairman of the Trafford Park Estates, Limited. Mr. H. A. Reed, engineer of the Manchester Ship Canal. Mr. F. A. Mollitor and Mr. E. P. Goodrich, of New York, who kindly replied to my inquiries addressed to the late Dr. Elmer Corthell. The Brown Hoisting Company, Cleveland, Ohio, U.S.A., Messrs. William Cory and Sons, and their engineer, Mr. H. Shoosmith. Messrs. William Doxford and Sons, Limited. The Link Belt Company, Nicetown, Philadelphia, Pa., U.S.A.; Messrs. Rownson, Drew, and Clydesdale, London; Messrs. H. Simon and Company, Manchester; Messrs. Spencer and Company, Melksham; Mr. Arthur Williams, of Messrs. Samuel Williams and Sons.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Council of the Institution of Electrical Engineers have elected Professor George Carey Foster, LL.D., D.Sc., F.R.S., past-president, to be an honorary member of the Institution.

JAPANESE STEEL MANUFACTURE.—We read in *The London and China Telegraph* that the Oriental Steel Manufacturing Company, organised by Baron Shibusawa, Mr. Buyei Nakano, and other prominent Japanese financiers, is now reported to have finished its general plan. The company is capitalised at 25,000,000 yen. It plans to produce 170,000 tons of pig-iron annually. The mills will turn out 200,000 tons of steel, with scrap iron and iron ore, out of which 150,000 tons of steel materials will be made. Iron ore will be obtained from the Tochun mines in Manchuria and other mines in Korea. The first three years will be spent in the establishment of the foundry and its manufacturing equipment. Besides iron and steel products, coke will be produced.

COMPRESSED GASES.—Another combine of considerable importance has just been brought about in Germany, viz., between the leading oxygen and hydrogen firms, the concerns in question being the chemical works of Griesheim-Elektron Company, the Linde Refrigerating Machinery Company, Wiesbaden, and the German Oxyhydric Company, Mannheim. These three concerns, which are of about equal size, control some 30 factories, distributed all over Germany. The remaining works are of no significance, and the combine really means a production and trading monopoly, in the first instance, in oxygen and hydrogen, but not carbonic acid. A certain understanding had for some time existed between the first-named companies, which, at least, in this matter did not compete against each other, but there was keen competition between them and the German Oxyhydric Company, in which the two former concerns have now jointly acquired a controlling influence. Nothing has yet transpired as to how the new combine will be worked, only it has been stated that the Oxyhydric Company will be continued on the previous lines. The companies manufacture also plant and apparatus for the production of oxygen and hydrogen, &c. The present quotations per cubic metre of oxygen and hydrogen, for private consumers are respectively 70 pfennig and 40 pfennig, against 55 pfennig and 30 pfennig before the war. Other rates probably apply to the large army contracts. (28.3 cub. m. = 1,000 cub ft.)

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on some Colonial and foreign engineering projects taken from the *Board of Trade Journal*. Fuller information on these can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia (*New South Wales*).—The Sydney Office of H.M. Trade Commissioner in Australia has forwarded a copy of the specification and conditions of tender in connection with a call for tenders by the New South Wales Department of Public Works for the supply and erection of pumping machinery in two units, driven by suction gas or by steam, for the Inverell water supply. Sealed tenders, on the proper forms, will be received, up to 2 p.m. on January 8, 1917, at the Department of Public Works, Sydney (N.S.W.), whence also copies of the specification and form of tender may be obtained. Tenders for amounts between 500*l.* and 1,000*l.* must be accompanied by a deposit of 10*l.*, whilst for tenders amounting to 1,000*l.* and over the deposit is to be 1 per cent. of the total amount (maximum deposit 500*l.*). A copy of the specification, conditions and form of tender, &c., may be inspected by United Kingdom manufacturers of pumping machinery at the Department of Commercial Intelligence as above.

Spain.—With reference to a previous notice in the *Board of Trade Journal* of October 5, relative to calls for tenders by the municipality of Barcelona for the carrying out of street drainage and sewerage works in that city, it is announced in the *Gaceta de Madrid* of October 11 that tenders will be opened at the "Casas Consistoriales," Barcelona, on November 17, for the carrying out of additional works of a similar nature, at a total estimated cost of 588,849 pesetas (about 25,000*l.* at current rate of exchange). The conditions of contract contain clauses to the effect that at the first competition the materials to be used will be confined, with certain exceptions, to products of Spanish manufacture, but that, in the event of no decision being arrived at, a second competition, in which foreign products may be accepted, will then take place. In the latter event, Spanish products will have a 10 per cent. margin of preference over foreign. The issue of the *Gaceta* referred to, containing the conditions of tender and detailed particulars (in Spanish) regarding the works to be carried out and the materials to be used, may be consulted by United Kingdom firms interested at the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C.

HIGH-PRESSURE AIR-COMPRESSORS.*

By JOSEPH M. FORD.

(*Continued from page* 395.)

Throttling.—In a compressor which has its suction throttled the volumes dealt with by the stages are of course reduced, which naturally involves a decrease in stage pressures. In a compressor with no cylinder clearances there would be no limit to the possible compression ratio in any cylinder; that is, the initial pressure in, say, the high-pressure cylinder could be very low and yet the machine would deliver air. But in a cylinder with a large clearance there is obviously a definite limit to the ratio of compression if air is to be delivered. If this ratio were exceeded the air would simply be compressed into the clearance space and re-expanded. In other words, in order that the compressor shall deliver air, the intermediate-pressure delivery pressure must attain a definite figure, so that the total work is still divided between the stages, although not necessarily in correct proportion. The theoretical minimum initial pressure from which a cylinder can compress and just deliver (assuming no leakage) can be obtained from the equation:—

$$c\left\{\left(\frac{P_1}{P_2}\right)^{\frac{1}{n}} - 1\right\} = 1$$

where

c is the clearance ratio,

P_1 is the delivery pressure (lb. per sq. in. absolute),

P_2 is the minimum initial pressure (lb. per sq. in. absolute),

and n is the exponent in PV^n = constant.

The above expression shows that P_2 increases as c is increased, and that with large clearances the compression ratio in any stage when the compressor is running throttled can be kept within limits, whereas in a machine having very small clearances the high-pressure compression ratio, with excessive throttling, might reach an abnormal figure, resulting in excessive temperatures in that cylinder. The foregoing would tend to show that a compressor with good clearance volumes is preferable to one with small clearances, and for some Diesel engines—especially those of the marine type, where the conditions under which the compressor works may vary between fairly wide limits—this is the case.

As previously mentioned, clearance results in a reduction in the effective capacity of a cylinder, so that larger cylinders must be fitted than would be necessary with no clearance volume.

The direct result is an increase in the piston loads. For example, a compressor of 300 cub. ft. per minute displacement at 350 r.p.m., having stage pressures of 45 and 300 lb. per square inch, when working at 900 lb. per square inch delivery pressure, and cylinder clearances for low pressure, intermediate pressure and high pressure of 4, 5 and 10 per cent. respectively, has a maximum air

* Paper read before the Greenock Association of Shipbuilders and Engineers.

load on the high-pressure piston of about 7,900 lb., whilst the maximum intermediate pressure piston load is 14,300 lb. In a similar machine having, however, low pressure, intermediate pressure and high pressure clearances of 4, 15 and 30 per cent. respectively, the high-pressure piston load is increased to 12,100 lb. and the intermediate pressure load to 22,800 lb. Figs. 12 and 13 give for various clearance ratios the maximum piston loads for compressors of the above capacity and stage pressures.

Fig. 14 shows the combined indicator diagrams for three machines, whose pressure characteristics are shown in Figs. 12 and 13. Inspection of the diagrams superimposed shows that as the clearance is increased the commencement of delivery and the commencement of suction, in both the intermediate-pressure and high-pressure cylinders, occur later in the stroke. With a large clearance, therefore, the maximum cylinder load is not attained until the crank is at a somewhat smaller angle from the dead centre than would be the case in a machine with no clearances, due to the fact that the actual compression takes place during a longer portion of the stroke, and further, the re-expansion of the greater volume of clearance air occupies a larger portion of the stroke, so that the pressure acting on the piston does work on the crank through a greater angle than it would were the cylinder clearances small. The crosshead load (neglecting inertia and weights of parts) at any point in the stroke, for the particular type of machine under consideration, is the difference between the intermediate-pressure piston load acting upwards and the low-pressure and high-pressure loads acting downwards, so that with the increased clearances the greater loads in the high-pressure and intermediate-pressure cylinders tend to balance one another to some extent. The result of this is that although the actual piston loads are considerably increased with large clearances, yet the maximum turning moment is augmented to a much less extent.

Fig. 15 gives the turning moment diagrams for two of the three compressors previously mentioned, namely, that with the 10 per cent. high-pressure clearance and that with the 30 per cent. high-pressure clearance. It will be seen that the maximum value occurs in this case when the crank is about 65 deg. from top centre. The comparatively small increase in maximum turning moment with the larger clearance, compared with the increase in the actual piston loads, is to be noted. The effect of the increased clearance volumes on the crank angles at which the various events of the cycle occur is also clearly seen.

Fixing of Stage Proportions.

When a machine is required to deliver a given quantity of air at a given pressure, one of the first decisions concerns the number of stages in which the compression should be effected. The main factors are: the initial cost of the machine, reliability and economy in operation, and safety in operation.

The initial outlay increases as the stages are multiplied. With a small machine the gain in economy and safety in operation due to increasing the number of stages is of less importance than in a large one. Cooling will be more effective due to the smaller cylinders, and the castings will probably be more reliable, thus lessening the chances of breakdowns. In addition, piston leakage in a small two-stage machine will probably be much less than in a three-stage machine of similar capacity, because in the former there will only be leakage past two sets of rings, whereas in the latter there are three sets. Moreover, the high-pressure piston in the two-stage compressor will obviously be larger than that of the three-stage one, so that the piston rings are much more likely to be air-tight. It is a recognised fact that in practice small rings, in spite of the smaller circumference, are more difficult to make tight than large ones.

The necessity for reliability demands, for reasons previously mentioned, that the temperatures in the cylinders be kept as low as possible, which in large machines, where the cooling is comparatively poor, demands division of the compression into several stages.

An important point in the computation of stage proportions is to arrange as far as possible for equal temperatures in each stage, for then the highest temperature is a minimum. Theoretically, this can be attained by dividing the work equally between the stages—which also results in the minimum of work required per unit of air compressed. In practice this is only true when the cooling effect is the same for all stages and the intercooling perfect.

Fig. 16 shows the theoretical theta-phi diagram for a three-stage compressor delivering air at 900 lb. per square inch gauge pressure. With equal division of work between the stages and intercooling down to the initial atmospheric temperature, the heat equivalent of the work required per lb. of air is represented by the area under ABHMPGR down to the line of absolute zero temperature (diagonal shading). The cooling effect is assumed to be the same for all stages, and as a result it will be seen that the maximum temperatures attained are the same for each stage of compression, viz., 260 deg. F. The distances *a*, *b*, and *c* are, of course, equal, since the compression ratios of the stages are identical.

Supposing that, owing to restricted water supply, climatic conditions, or circumstances connected with the design of the machine, it is found that in the first stage intercooler the air can only be reduced in temperature to 90 deg., and in the second stage intercooler to 120 deg., then the diagram is modified as shown by the dotted lines. The heat equivalent of the work required per lb. of air will then be represented by the area under ADJLOGR down to the line of absolute zero temperature, the excess over the previous case being represented by the horizontally shaded portions. The temperatures attained in the stages are no longer equal, but increase towards the final delivery. In this case they are: low pressure = 260 deg., intermediate pressure = 300 deg., high pressure = 340 deg. The compression ratios of the stages are, however, still equal.

With the poor intercooling, even, the maximum temperature of the cycle can be reduced by changing the distribution of work between the stages.

If the compression ratios in the various stages are made in the proportion $x : y : z$ (see Fig. 16), then the stage

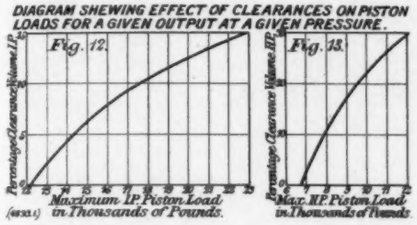
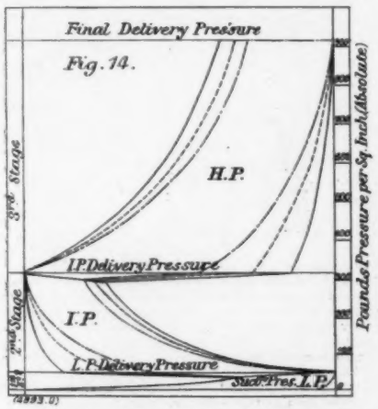


DIAGRAM SHEWING EFFECT OF CLEARANCES ON PISTON LOADS FOR A GIVEN OUTPUT AT A GIVEN PRESSURE.
Fig. 12.
Fig. 13.
Maximum I.P. Piston Load in Thousands of Pounds.
Max. H.P. Piston Load in Thousands of Pounds.



Combined Diagrams for Three Machines designed for the same Output and Stage Pressures.

———— For a machine with clearance volumes—L.P., 4 per cent., I.P., 5 per cent., H.P., 10 per cent. of volume swept by piston.

– – – – – For a machine with clearance volumes—L.P., 4 per cent., I.P., 10 per cent., H.P., 20 per cent. of volume swept by piston.

– · – · – · For a machine with clearance volumes—L.P., 4 per cent., I.P., 15 per cent., H.P., 30 per cent. of volume swept by piston.

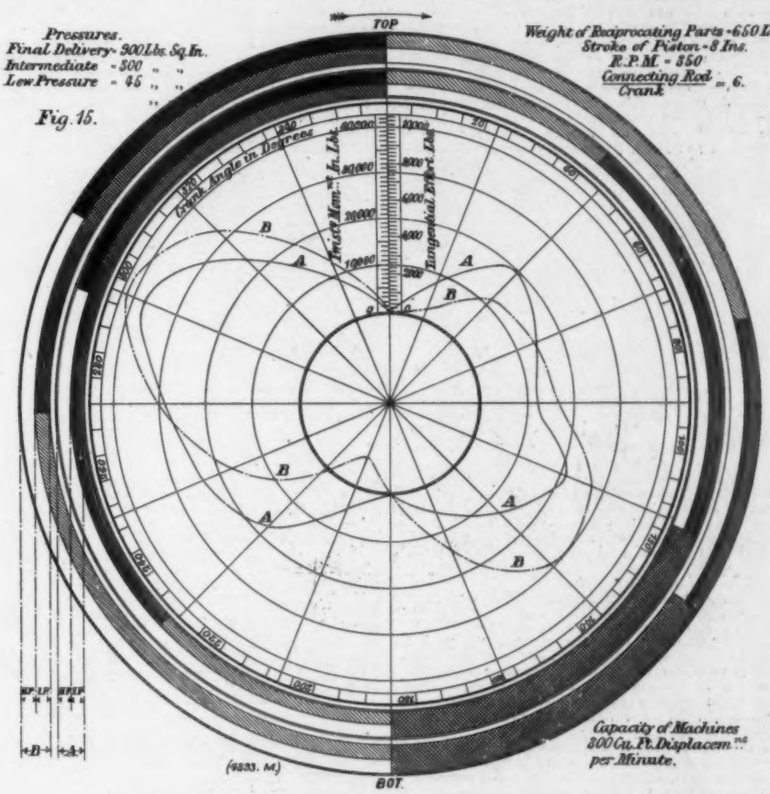

Pressures.
Final Delivery - 900 Lbs. Sq. In.
Intermediate - 300 " "
Low Pressure - 45 " "
Fig. 15.
TOP
BOT.
Weight of Reciprocating Parts - 650 Lbs.
Stroke of Piston - 8 Ins.
R.P.M. - 350
Connecting Rod / Crank = 6.
Capacity of Machines 300 Cu. Ft. Displacement per Minute.

Diagram of Twisting Moments and Crank Angles for Various Events of the Cycle.

(A)—For a machine with clearance volumes—L.P., 4 per cent., I.P., 5 per cent., H.P., 10 per cent. of volume swept.

(B)—For a machine with clearance volumes—L.P., 4 per cent., I.P., 15 per cent., H.P., 30 per cent. of volume swept.

Final delivery period, black; re-expansion of clearance air, single hatching; suction from intercoolers, circular hatching; transfer periods, cross hatching; compression periods, blank.

The diagram for the L.P. points will be practically identical for the two machines, and is therefore not given.

adiabatic compression as a result of the addition of the said heat. Later on in the stroke cooling sets in and the compression becomes further removed from the adiabatic, shown by the line bending over to the left.

The atmospheric temperature is assumed to be 60 deg. F. The point "X" represents the initial condition of the air in the low-pressure cylinder just before compression begins, and it will be observed that the temperature has been increased by the amount Δt_1 (in this case 20 deg.), the increase being due to the fact that the air on its way to the cylinder has become heated through contact with hot valves, &c. In this particular case, with a mechanically controlled suction valve, the initial pressure is seen to be very slightly above 14.7 lb. per square inch, due to the inertia of the moving column of air in the suction pipe.

The first stage compression is carried to 59.7 lb. per square inch absolute and the temperature rises to 320 deg. F., the large rise being due to the fact that cooling is rather bad in this stage, partly as a result of a large portion of the "cover" being occupied by the high-pressure cylinder and the rest by large delivery valves, so that cooling cannot well be applied to this part. From the diagram it will be seen that the resultant compression is almost adiabatic.

After the first stage of compression the air is cooled in the intercooler to 80 deg. F., but on entering the second stage cylinder it again increases in temperature Δt_2 due to the hot piston, passages, &c., and also as a result of mixing with the re-expanded clearance air. The restriction in the intercooler tubes and in the valves results in a pressure drop, so that the initial second stage pressure is somewhat lower than the low pressure delivery pressure.

The total effect, then, of the above is that the initial condition in the second stage cylinder is represented by point "Y" instead of point "J," as would be expected.

It is assumed that the large clearance space in the intermediate-pressure cylinder is well cooled, and this, together with the good jacketing effect, results in the compression being further removed from the adiabatic than it is in the low-pressure cylinder, so that in spite of the considerably greater share of the work done by the intermediate-pressure, the temperature of compression is not very much in excess of that in the previous stage. A similar sequence of events takes place in the high-pressure cylinder, where, again, owing to the large well-cooled clearance, compression is within the adiabatic. This, together with the fact that the high-pressure stage has the smallest share of the work to do, results in the comparatively low final temperature of 240 deg. F.

Even with a poor distribution of work, as in this case, the temperatures need not necessarily be excessive. There are, however, other aspects of the problem of determining stage proportions. Consider the case of a high-speed Diesel engine compressor, where it is desirable that the balance and twisting moment diagram of the machine should be as good as practicable, in order as far as possible to eliminate vibration.

With a machine of a certain type, it will be obvious that the crosshead load at the top centre will be due to both the low-pressure and high-pressure delivery pressures on their respective pistons, whilst at the bottom centre the load is only that due to the intermediate-pressure pressure. The maximum upwards load is then about twice the maximum downwards load, which would not conduce to the best running.

There are two ways of bettering conditions, one of which is to retain the stage pressures and adjust the intermediate pressure clearance until the load approximates to that desired (see Figs. 12 and 13), and the other is to choose the stage pressures so that the up load is reduced and the down load increased. Increased down loads necessitate larger connecting rod bolts, which in some cases, on account of the restricted space available, might not be easily accommodated.

Provision for Variable Delivery Pressures and Volumes.

Another consideration when fixing stage proportions is the possibility of the machine being run at delivery pressures higher than normal.

In the remarks on clearance this question was mentioned, and the advantages of large clearances in this connection were enumerated.

The loads to which large clearances give rise (Figs. 12 and 13) might be inadmissible for various reasons, whilst the increased cost due to the larger cylinders might be a disadvantage, so that the constant proportional division of work between the stages, almost always approximately possible of attainment by choosing suitable clearances, would not in this case be secured.

If the machine runs at a pressure above its normal the division of work will be upset, and the high-pressure stage will take a considerably increased share of the total load, which may result, among other things, in an undue rise of final delivery temperature. If this latter is reasonably low when the machine is working at normal pressure, the rise due to the increased pressure will not be of such great consequence. To meet these conditions it is usual to arrange that the high-pressure stage shall, under normal conditions, take rather less than its proper share of the total work. The temperature in the other stages will be somewhat increased, but the rise in these temperatures due to the small increase in pressures as a result of the greater delivery pressure is inconsiderable.

If the machine has to run throttled in order to reduce the volume delivered, then it is again desirable, if possible, to arrange that the high-pressure stage shall under normal conditions take the smallest share of the work, since throttling reduces the stage pressures without altering the delivery pressure, thereby resulting in an increased high-pressure delivery temperature.

The importance of keeping the high-pressure temperatures low may again be emphasised. Burning and explosion of the lubricating oil here is of great violence when it does occur, which happily is very rare, due, among other things, to the attention given to the selection of the oil itself.

Volumetric Efficiency.

One other point which arises in connection with the determination of stage proportions is the question of the volumetric efficiency of the low-pressure cylinder. If the low pressure stage is given a large share of the work, the effective capacity of the machine will be less than it would be with a lower first stage delivery pressure for reasons explained in the notes on the effect of clearance.

From the above it will be seen that multi-stage compressor design is to a large extent a matter of compromise. Each case should be treated by itself according to the duty of the machine and conditions under which it is to run, and the best combination under the circumstances of loads, balance, and temperatures should be found, whilst the behaviour when throttled or running at various pressures must also be considered.

The question of cost should not be forgotten, for in some cases the advantages gained by, say, adding clearance, and thereby increasing cylinder sizes, may not warrant the additional expenditure.

Cylinder Proportions.

Fig. 18 shows the stage pressures adopted in some of the very latest three-stage compressors for Diesel engines, by four different British and Continental builders, and bears out the remarks regarding the compromise in design of compressor.

Having decided on the stage pressures and cylinder clearance ratios, the actual determination of main dimensions is relatively simple.

When fixing the cylinder sizes, the low-pressure cylinder is settled first, as in a steam engine. A low-pressure delivery pressure is assumed—basing the assumption on previous practice if available—and from this pressure and the clearance volume in the cylinder (depending largely upon the type of valves used) the indicated volumetric efficiency is calculated. The dimensions of the cylinder are chosen such that, after the clearance air has re-expanded, the cylinder can draw in the required amount of air, plus an allowance for leakage through the compressor. Regard should also be paid to the fact that the air on its way to the cylinder, through contact with hot valves, passages, &c., becomes heated—which reduces the actual weight of air dealt with.

Where the workmanship is of the first order, about 85 to 90 per cent. of the air actually taken into the compressor will be delivered when compressing to 1,000 lb. per square inch in three stages.

The second stage cylinder is proportioned so that after its clearance air has expanded it can contain the whole of the air delivered by the low pressure at the low-pressure delivery pressure, and at the temperature resultant upon the mixing of the incoming and the clearance air. Attention should again be given to the effect of the hot cylinder cover, piston, &c. The other stages are similarly treated.

Experience is an important factor in the settling of cylinder proportions, as in the higher stages, at any rate, it is essential that allowance be made for leakage. For example, in a four-stage machine compressing to 3,500 lb. per square inch, possibly not more than 80 per cent. of the air taken in ever reaches the high-pressure cylinder. If this cylinder is made big enough to deal with the whole of the air aspired by the machine, it would actually take considerably more than its intended share of the load.

One method of finding the volumes of the various cylinders is the "constant weight" method, which depends on the fact that (neglecting leakage) the weight of air in all the cylinders at the end of the suction stroke is the same, correction for leakage being made afterwards. Another method, which can be used graphically, is the "equivalent cylinder" method. Here the volumes of the ideal cylinders with no clearance are found, assuming the compression isothermal, and an adjustment is then made for the effect of clearance air and temperature rises.

When the cylinder sizes have been determined, the size, location and number of valves may be fixed, determining to a great extent the way in which the necessary clearance volume is made up.

Small deviations are often made from the theoretical figures for reasons of manufacture. Supposing that the calculated high-pressure cylinder diameter was 3½ in., for convenience of manufacture this dimension might possibly be made the more even figure of 3¼ in., entailing, however, an increase of 7½ per cent. in the volume. Some builders, however, work to sixteenths of an inch in cylinder diameters.

(To be continued.)

Motor Shipbuilding in Germany.—The Allgemeine Elektricitäts Gesellschaft is about to erect engineering works in Hamburg for the purpose of building two-stroke marine Diesel motors and large motor vessels.

Pressures are in Pounds per Sq.In. Absolute.
Temperatures are in Degrees Fahrenheit.

Fig. 16.

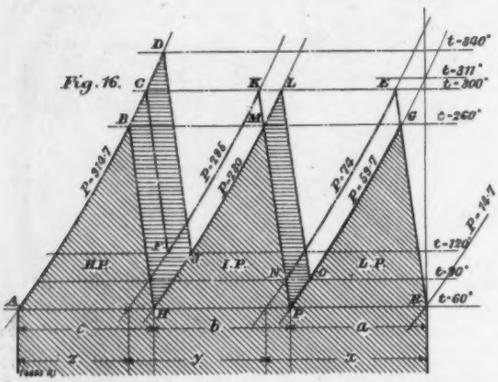


Fig. 17.

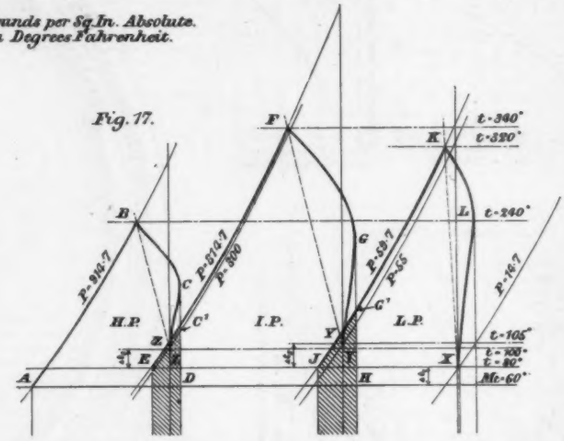
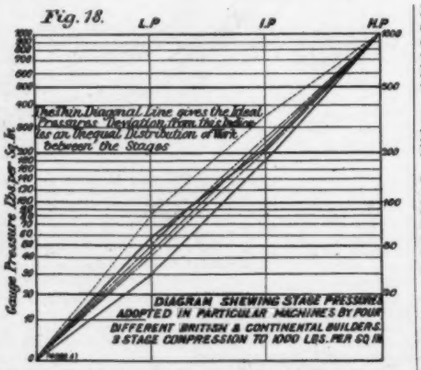


Fig. 18.


L.P
I.P
H.P
Gauge Pressure Lbs per Sq. In.
The thin Diagonal Line gives the Ideal Pressures. Deviation from this implies an Unequal Distribution of Work between the Stages
DIAGRAM SHEWING STAGE PRESSURES ADOPTED IN PARTICULAR MACHINES BY FOUR DIFFERENT BRITISH & CONTINENTAL BUILDERS. 3 STAGE COMPRESSION TO 1000 LBS. PER SQ. IN.

Note.—This chart may also be used to determine the ideal stage pressures (i.e., equal compressions per stage) for compression to pressures up to 1,000 lb. per sq. in. in 2 or 3 stages. For 3 stages of compression a line from the zero point to the intersection of the delivery pressure line and vertical H.P. cuts the other verticals in the ideal pressures. Example: 3 stage compression to 500 lb. per sq. in. gives—L.P. pressure = 33 lb. per sq. in. and I.P. pressure = 142 lb. per sq. in. gauge. For 2 stage compression join zero point to intersection of delivery pressure line and vertical I.P. L.P. pressure can then be read off as before.